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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Competing Industries and Standardisation

It is probably true to state that there is a greater urge for standardisation amongst buyers than sellers, bearing in mind that, when related to firms, each concern has a dual "personality." Thus, in the foundry industry, there is a greater enthusiasm for buying pig-iron or coke to specified conditions than for selling their products under like conditions. This, of course, is not universally true, and the efforts made to reduce the number and types of castings used in the rain-water goods trade have in general been welcomed as a factor contributing to the reduction of manufacturing costs.

There are, however, many types and ranges of casting where efforts have been made, by improved or more artistic design, by compositional amelioration and control or by processing to provide an article bordering on the unique in its effectiveness. The more successful firms look askance when they see attempts being made to embrace their specialities under the all-embracing specificational requirements. Moreover, nowadays it is not merely firms which compete for a given market; it is often industry against industry. In this case, the scramble for supremacy becomes one which in any analogous sphere of activity would involve either Royal Commissions or High Court actions. A case which readily comes to mind is that of cast iron or steel pipe for public utility undertakings, where a badly phrased specification could weight the scales very unfavourably against either the one side or the other. A second case is that of lamp standards. Here the competing industries are the foundry, the steel tube and the concrete manufacturer. With the interest now being taken in the main roads by the Ministry of Transport, conditions might arise for the standardisation of these nowadays essential articles. If ever there was a case against standardisation, surely this is the strongest. Half the pleasure of a Continental holiday is the fact that railway rolling stock, petrol service stations, and the rest of human creations take on a somewhat different appearance. We suggest in all seriousness that such matters as lamp standards should be designed to suit the purely local conditions. In a new industrial estate, with a mass of reinforced concrete or stucco-faced buildings, reinforced concrete lamp standards would be æsthetically correct, but would look out of place in The Mall. Where a road passes through rural areas, they should be as unobtrusive as possible, but in the cities, decorative bases of cast iron can, and do, help to smarten up the general appearance of a road. Westminster, for instance, is particularly well served in this respect. The objection launched against cast iron is its fragility, but surely efforts should be directed towards removing the cause of impacts and not their effects.

Riddle of the Sands

During the past few years real progress has been made both in this country and abroad relative to the properties required of mould and core sands for the production of sound castings. It would appear, however, that there is a distinct tendency to base fundamental facts upon conclusions reached by individual practice, which is to be regretted as in many instances this only serves to confuse the real issues at stake. There is no greater variable between foundries than the type of sand employed, and it is only reasonable to assume that properties which may be thought of importance by one investigator might play only a minor part in another foundry operating with different methods and materials.

This statement applies much more forcibly to-day than formerly, particularly when any attempt is made to outline fundamental factors leading to the cause of scabs and other mould surface defects. In the earlier stages of sand testing simple tests assessing properties at room temperature in conjunction with foundry technique appeared to offer satisfactory explanation as to the cause of many casting troubles. It is now appreciated, however, that tests conducted in this way only tell part of the story and our knowledge will not be complete until reliable information is on hand indicating the changes that take place when sands are heated and performing their intended function. In this country foundrymen are indebted to Mr. F. Hudson for first drawing attention to this important matter, and in this column in our issue for December 5, 1935, we made a plea for the need of further work being done so that Mr. Hudson's work could be confirmed and the general fundamentals made available to cover the trade as a whole. Several investigators have since given thought to this matter, particularly in connection with changes in volume of mould and core materials at elevated temperatures. It would now seem that, following the most recent work of Mr. Dietert in the United States, published in our last issue, together with the findings of Mr. R. F. Hudson, published elsewhere in this present issue, the question of *expansion and contraction* is of very great importance to the modern foundryman.

British Foundry School

The British Foundry School session 1937-38 closed on July 22. The fourth session opens on September 20, 1938, and the entries already received suggest that the number of students will be decidedly larger than during the past two sessions.

A special feature of the past year was the arrangement of the annual visit which this time was made to Belgium and France. In Brussels the foundries of Société des Fonderies Nestor Martin, the well-known works making stoves and cookers, including enamelled ware, were seen, Mr. Eugène Verhaeghe of the company acting as guide round the works and laboratories. Four visits were then paid to large and important foundries in the Liège district, and in this connection the warmest thanks of the School are due to Mr. Léonard, Past President of the A.T.F. de Belgique, and Mr. Deprez, the Honorary Secretary. This group of visits was to the Société Metallurgique d'Esperance Longdoz, under the guidance of Mr. Varlet; S.A. John Cockerill, under the guidance of Mr. Proyard and Mr. Gillian; S.A. des Conduites d'Eau and the S.A. Maréchal Ketin, under the guidance of Mr. Borgheroff. At Charleroi the party saw the Union des Aciéries à Marcinelle, guided by Mr. Cambier and Mr. Dewier, and the Fonderie Cognioul, guided by Mr. Bronckart and Mr. E. Coginoul, the former being a very fine steel foundry and the latter a well-known non-ferrous foundry making brasses and bronzes and special alloys. The group covered practically every aspect of production of foundry pig-iron, light and heavy iron and steel and malleable castings and non-ferrous castings.

The party proceeded to Paris for Saturday morning to visit the Ecole Supérieure de Fonderie. It was received by Prof. Portevin, the Director, and joined the French students to hear a lecture by Prof. Chevenard, before seeing the buildings and those of the Ecole d'Arts et Métiers in which the school is housed. The Governors of the British Foundry School are greatly indebted to the gentlemen mentioned for their courtesy and assistance in making the visit the great success it was.

During the Easter vacation a special course organised by the Board of Education and conducted by Dr. F. T. Chapman, H.M.I., was held at the School for full-time and part-time teachers of foundry subjects from technical and junior technical schools and colleges. Methods of teaching foundry subjects for national certificate and City and Guilds examinations were considered, recent advances reviewed and special difficulties of conducting classes for foundry employees were discussed. Visits were paid to the Midland Motor Cylinder Company, Limited, and the Midland Electric Manufacturing Company, Limited. Nine lectures were given by the Lecturer-in-Charge and associate lecturers to the Foundry School.

Catalogue Received

Conveyors. The Fraser & Chalmers Engineering Works, Erith, Kent, have published a particularly interesting brochure giving full information about "Webb" conveyors. This range includes floor, overhead power-driven, creeper and slat conveyors. Obviously, the applications of such a variety of systems are particularly wide, and amongst the duties now being undertaken in this country is handling lawn mowers and parts through enamelling furnaces. The principal field covered is the movement of motor-car parts. The pages, which are well illustrated, present a mass of high-grade technical data.

Bradford Conference Fund

Members of the Foundry Trades' Equipment and Supplies Association contributed a sum of £64 10s., and the following is a list of firms which responded to the appeal through the Association:—

Sir W. G. Armstrong Whitworth & Company (Ironfounders), Limited.
August's, Limited.
Bradley & Foster, Limited.
The Louis Cassier Company, Limited.
Coleman Foundry Equipment Company, Limited.
Constructional Engineering Company, Limited.
William Cumming & Company, Limited.
Fordath Engineering Company, Limited.
Foundry Plant & Machinery Company, Limited.
The Foundry Trade Journal.
General Refractories, Limited.
Spermolin, Limited.
Sterling Foundry Specialties, Limited.
Universal System of Machine Moulding & Machinery Company, Limited.
Thomas Wilkinson & Company, Limited.

Mr. W. G. Thornton, the Honorary Treasurer of the Institute of British Foundrymen 1938 Conference Fund, has sent us his final list of subscribers as follows:—

	£	s.	d.
Thos. W. Ward, Limited, Sheffield ...	5	5	0
Hill Bros., Leeds	5	5	0
Calvert & Company, Limited, Huddersfield	5	5	0
Roberts Castings, Limited, Huddersfield	5	5	0
United States Metallic Packing Company, Limited, Bradford	5	5	0
Mr. N. C. Ashton, Huddersfield ...	5	0	0
Mr. F. K. Neath, Leeds...	2	2	0
Charles Buckle & Company, Bradford	2	2	0
Taylor & Parsons, Limited, Bradford	2	2	0
Mr. G. G. Mennell, Harrogate ...	2	2	0
Mr. W. Parker, Bradford	2	0	0
Mr. T. Wolverson, Leeds	1	1	0
Mr. F. Milnes, Bradford	1	1	0
Mr. W. Hird, Bradford	1	1	0
The Horsforth Ganister Company, Leeds	1	1	0
Mr. G. Copeman, Leeds	1	0	0

Catalogue Received

Oil-Retaining Bronze Bearings. When the reviewer dealt with some earlier publicity matter issued by the Phosphor Bronze Company, Limited, of 54, St. Thomas Street, London, S.E.1, he sought for information as to the usefulness of Compo H oil-retaining bearings for foundry machinery, owing to alleged complete disregard by foundrymen for routine lubrication. So far as our readers are concerned, the claim which is outstanding is "Freedom from lubricating difficulties." Apparently these Compo H bearings absorb about 30 per cent. by volume of oil and "in the majority of applications additional oil is not required." The new brochure, which contains eight pages, gives details of its composition, mechanical properties and a micro at 75 diameters. This, unfortunately, is printed on buff paper, which detracts markedly from its true value. Firms catering mainly for the foundry industry never do this nowadays. Against the back cover is an intelligently compiled tear-off data sheet. This catalogue is available to our readers on application to the Phosphor Bronze Company.

Notes from France

By Our Special Correspondent.

French foundry owners continue to complain of the poor volume of business. Little hope is held out of any improvement in the situation before October or November, as with the holiday period coming on, volume of business is always reduced to a mere trickle. Certain of the blast furnaces, which hold contracts for the production of gas or electricity as by-products, continue to operate beyond their actual commitments in pig, in order to keep working and to get in such money as they can from the by-products, in the hope of being able to dispose of the pig later. Some of these plants, however, now have as much as six months' production of iron on hand and are beginning to consider the advisability of closing down. This would have serious effects on the industries using the gas and electricity.

A great many foundries have completely empty order-books and can execute work without delay. An exception must be made for plants working for the National Defence, which continue to do satisfactory business. There is also a certain volume of business as regards special castings for naval constructions and compressors. General trend of business is so poor, however, that about half of the firms existing ten years ago have either closed down or gone out of business altogether. The most recent case is that of the Fonderies Broglin at Chauny, who have offered their plant for sale.

Foundries and the Social Legislation

On the occasion of the ceremony of presenting the Gold Medal of the Foundry Technical Association to Mr. Luc, Inspector General of Technical Education, Mr. Olivier, the President of the Foundry Employers' Federation, commented on the effects of the social legislation on the foundry trade. He stressed the fact that the social legislation is both necessary and good, but insisted that it is dangerous to slow down production possibilities in the name of social progress. This, he felt, was exactly what the 40-hour week act did in its present form. Describing the law as suicidal, he insisted on the need for replacing it by an act limiting work to 2,000 hours per year, with the possibility of overtime work when necessary. It was realised that men cannot, with a 40-hour week, turn out more than they are now doing, but it was also realised that with five 8-hour days it was not possible to work economically.

Proposed Pattern Standardisation

In a lecture to the Association Amicale et Mutuelle de Fonderie, Mr. Cape has suggested the creation of a system of standards for the description of patterns in order to avoid confusion or misinterpretation. He suggested that patterns be divided into 23 different types, each type conforming to a general description of the kind of work and material to be used in the pattern. Type 1, for example, would be a simple piece in white wood or other wood suitable to the patternmaker, comprising the desired fillets and left unvarnished. Type 2 is the same except that it includes core prints, whilst Type 3 uses core boxes. Type 4 is the same but with leather fillets glued on, while Type 5 is in hard wood and designed to stand up under use for the production of at least five castings. The other types correspond to various other materials and methods of construction. In favour of his system, Mr. Cape contended that it permitted a concise description without the need for long explanations.

Demag A.-G., Duisburg, have been awarded a contract by the Iranian Government for the construction of blast furnaces near Teheran.

The Practical Value of Controlling the Properties of Moulding Sands at Elevated Temperatures

By R. F. HUDSON

Some work has been published by F. Hudson,[1] and yet still more recently by W. Y. Buchanan,[2] on the effect of composition on the properties of moulding sands and the changes that may be brought about through the intelligent use of materials, such as coal dust, sawdust, and old firebricks, etc., on these properties at elevated temperatures.

The author wishes to give in this short Paper a few more recent practical experiences, whereby, by controlling the composition of the moulding sands, and so incidentally controlling the expansion and other variable properties at high temperatures, the result is more efficient foundry practice.

FOREWORD.

By Mr. Frank Hudson.

Since publication of the results of some personal work on the properties of sands at elevated temperature two years ago, some criticism has been raised relative to the effect of expansion on practical operations. It has even been stated that this factor has no effect as moulding sands exhibit no expansion on heating. This might be quite true for some sands, but it is also equally true that other moulding and core compositions in service do exhibit a marked expansion on heating.

In discussing this matter recently with one prominent foundryman a statement was made that scabbing due to metal impingement had been overcome by drastically increasing the clay content in dry sand, although the dried strength value was already ample to meet most conditions. The theory put forward as to the action of *excess* clay in this direction was that the silica grains in the sand expand on heating whilst the clay shrinks, and the expansion of the former can therefore be neutralised. It was added, however, that probably around 20 per cent. clay has to be present to have this effect.

This seems to be a perfectly logical theory, and indicates that the expansion characteristics of moulding and core sands can be expected to vary, and in certain cases might exhibit no expansion at all, particularly in the presence of excess clay. On the other hand, it is equally true that in the majority of instances sands will expand on heating and control of this factor, as the present Paper shows, is of considerable assistance to the practical foundryman.

It is not claimed that a sand with low or no expansion and with other satisfactory properties is perfect and will produce 100 per cent. good castings. Many other factors play their part in the production of satisfactory castings. A mould or core incompletely dried, a gagger placed too near the mould face or too free use of clay water and many other factors may condemn a perfectly good moulding sand. It is claimed, however, and substantiated later, that, given a sand with satisfactory high temperature properties and another sand without these properties, other things being equal, the sand with those good properties will always produce a much superior casting than the other sand with the poorer high temperature properties, especially when subject to unequal heating.

Practical Foundry Experiments

In the production of castings it is not considered good practice to gate them in such a way as to allow the metal directly to impinge on either mould or core surfaces. The ideal gate is one which will admit metal in sufficient volume to fill the mould in a period of time that will prevent cold shuts and will not subject the face of the mould or core to undue pressure or erosion. In the following series of tests the aforementioned precept was not followed. Three test moulds were rammed and cast, the method of running being as severe a test as possible, the molten metal directly impinging on the core at a very high casting temperature.

The idea was to manufacture three moulds under exactly similar conditions and cast in the same way, the one difference being that the core on which the metal impinged was made with a sand having a different composition, thereby altering its properties at high temperatures. The following factors were duplicated to ensure identical conditions in every respect:—

(1) The mould was rammed up in the same sand by the same individual.
(2) Distribution and size of gate and risers.
(3) Volume of metal poured.
(4) Casting temperature.
(5) Drying time.
(6) Blackwashing.
(7) Head of metal and pouring commencing at the same position in basin.

Fig. 1 shows a sectional drawing of the experimental castings, which weighed 128 lbs.

The three cores were also treated alike, their additions of carbonaceous materials being the only variable, the base sand being the same in each case. Table I gives the mixtures used, and their properties at both atmospheric and elevated temperatures. The first mixture was an ordinary drysand facing sand as used for castings up to 30 tons, the second and third being the same mixture but with increasing additions of sawdust. It is evident, that the physical properties of the three sands at atmospheric temperatures are very similar, the only variance being the properties at high temperatures, the No. 3 mixture having practically only 50 per cent. of the expansion of the No. 1 mixture and therefore the high temperature properties of this mixture are greatly superior to that of the first mixture which contains no sawdust. The three moulds were then cast, the casting temperature being 1,350 deg. C. Immediately the castings were cold, the moulds were stripped and the resultant castings wire brushed.

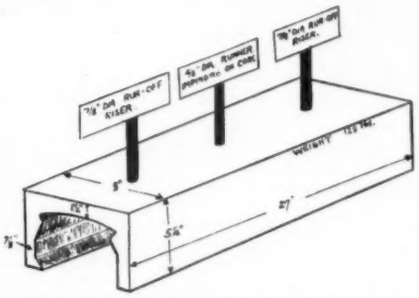
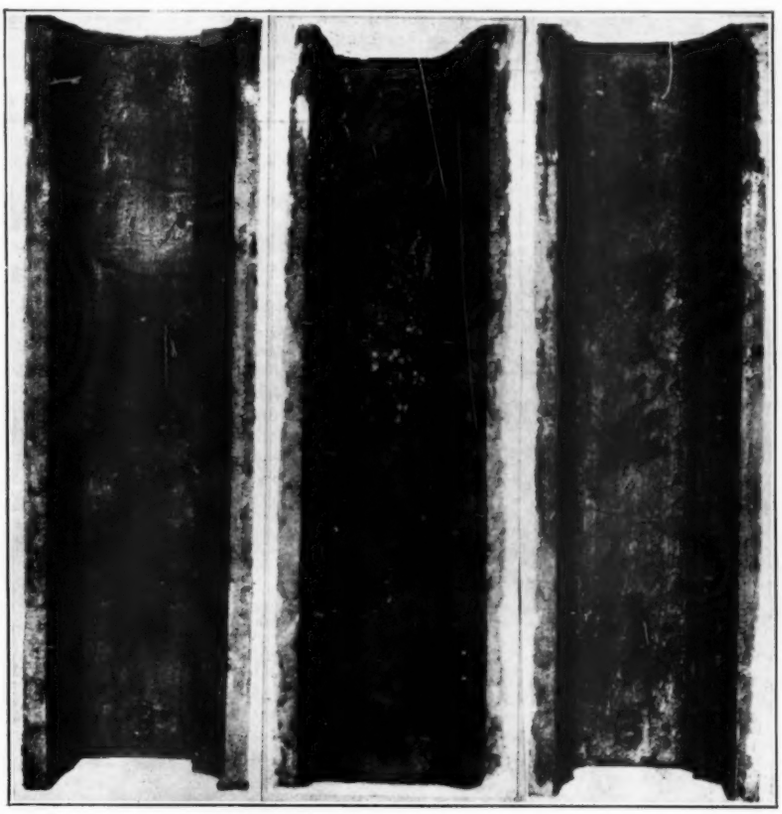


Fig. 1.—Sectional Drawing of the Experimental Casting.



Mix No. 1. Greatest Expansion. Mix No. 2. Mix No. 3. Least Expansion.

Fig. 2.—The Three Experimental Castings.

Fig. 2 shows the three castings made from these three sands under precisely the same con-

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[1] I.B.F. Proceedings, 1935-36, Vol. XXIX.
[2] Foundry Trade Journal, May 27, 1937, p. 423.

ditions. As can be seen No. 3 casting (that is the one with the least expansion) is quite satisfactory, while the other two are decidedly scabbed, the one with no sawdust and the greatest expansion being definitely the worst.

The action the sawdust has in producing better castings is simply explained. As the molten metal continuously impinges on that portion of the core beneath the gate, this portion of the core is soon heated to a higher temperature than that of the surrounding sand, and this is also accompanied by a big increase in strength. When 500 deg. C. is reached the sand or quartz begins to expand and being stronger than the surrounding core surface something has to give way so the face of the core buckles and causes a scab. Sawdust and other carbonaceous materials burn out and leave voids so as to relieve that expansion, they also promote a better finish and easier fettling.

One factor to guard against when using a sand with a high loss on ignition is to ensure a sufficient degree of permeability or artificial venting to cope with the extra gas evolved.

Further Tests Using Crushed Firebricks

It was being found in practice that when using ordinary drysand mixture (Table I, Mixture No. 1) and where the method of gating allowed the metal to impinge on the core scabbing was occurring. Several different attempts were made by altering the venting, etc., but no matter what was tried when gated in this way, defects occurred. When bottom-poured, the castings were quite satisfactory, but a new mixture was sought for, to withstand the top pouring and so necessitate no alteration in practice. This new mixture was soon developed and brought into use.

It was simply a mixture of old crushed firebricks plus 3 per cent. bentonite. This gave a very satisfactory sand and is perhaps the most foolproof one obtainable. It can be easily manufactured, any old refractory bricks, free from slag may be used and crushed in a mill to any grain size desirable.

Fig. 3 shows the design of the sidebox castings which were being scabbed. Whole moulds may be faced with this crushed firebrick mixture, but it was found quite sufficient only to face that portion of the core or mould directly beneath the gate, the remainder of the core or mould being rammed up in an ordinary dry sand facing sand. Table I Mixture No. 4 gives the physical properties of this sand at both atmospheric and elevated temperatures. As can be seen, both sands have similar properties, excepting again that property of expansion. The ordinary drysand mixture No. 1 which scabbed had an expansion of 27 thousandths of an inch on 2 in., while the crushed firebrick sand has no expansion.

Fig. 4 shows the sidebox where the runner bottoms had been lined with the crushed firebrick mixture, and is, as can readily be seen free from any scab or defects. Again it is considered that this test shows conclusively the advantage one has when one uses a sand with good high temperature properties over a sand with objectionable ones. This crushed firebrick mixture has proved invaluable for faces of the mould or core which have to withstand the prolonged flow or impingement of molten metal. In conclusion, it is obvious that the high temperature characteristics of moulding sands play a definite part in the production of castings, and proper appreciation of these properties is bound to be a valuable asset in practical foundry work.

Table I.—*Showing Properties of the Various Sand Mixtures Used to Eliminate Scabbing by Reducing Expansion.*

No.	Sand mixtures.	Blackwash mixture.	Drying time and casting temp.	Physical properties.						Per cent. loss on ignition.	Remarks.
				Per cent. moisture.	A.F.A. comp. strength. Lbs. per sq. in.			Dried perm. A.F.A. No.	Maximum expansion on 2 in.		
					Green.	After drying.	At 900 deg. C.				
1.	20 shovels drysand floor sand 10 shovels old oil sand cores 3½ lbs. Bentonite	5 parts water .. 1 part wood extract Blacking to suit	Blacked green .. Dried 1 night Cast 1,350 deg. C.	8.1	5.1	130.2	249.6	80.0	0.027	4.70	Very badly scabbed. Green core hardness, 52–78.*
2.	20 shovels drysand floor sand 10 shovels old oil sand cores 4 shovels sawdust 4 lbs. Bentonite	„ „	„ „ Cast 1,340 deg. C.	9.5	4.7	121.6	184.6	80.0	0.024	6.01	Very slight scabbing.
3.	20 shovels drysand floor sand 10 shovels old oil sand cores 6 shovels sawdust 5 lbs. Bentonite	„ „	„ „ Cast 1,340 deg. C.	10.2	5.2	129.6	128.0	76.0	0.016	6.63	Free from scabbing.
4.	97 per cent. old crushed firebricks 3 per cent. Bentonite	—	—	11.0	5.0	150.0	—	70.0	Nil	—	Free from scabbing.

* Dietert scale.

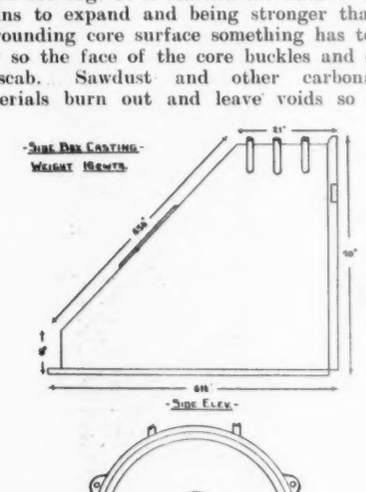

Fig. 3.—Sectional Drawing of Side Box Casting.

Fig. 4.—Photograph of Satisfactory Side Box Casting.

Iron and Steel Institute

NEW YORK MEETING

The very extensive programme for the New York meeting of the Iron and Steel Institute has now been completed and issued to members attending. It includes detailed travel arrangements, technical sessions, works to be visited, social functions, extended tours and return facilities.

Technical Sessions

The first technical session opens at 2.30 p.m. on Monday, October 3, in the Auditorium of the Engineering Societies Building, when the following Papers will be presented:—(1) "Recent Developments in the American Iron and Steel Industry," by C. E. Williams; (2) "The Development of Continuous Strip Mills," by D. Eppelsheimer, Jun., and (3) "Research and Development in the American Non-Ferrous Metal Industry," by Prof. C. H. Mathewson.

The second technical session will commence at 10 a.m. on Tuesday, October 4, in the Astor Gallery of the Waldorf-Astoria. The Papers to be read will be as follow:—(1) "American Electric Furnace Practice," by W. M. Farnsworth and E. R. Johnson; (2) "Electric Furnaces in European Steelworks," by D. F. Campbell; (3) "Grain Size and Hardenability in Steels to be Heat-treated," by E. C. Bain, and (4) "Modern Rolling-mill Practice in America (exclusive of continuous strip and sheet mills)," by Quincey Bent. Papers (1) and (2) will be discussed jointly and (3) and (4) separately.

The New "Mauretania"

The new "Mauretania" was launched at Birkenhead last week by Lady Bates, wife of Sir Percy Bates, chairman of Cunard White Star, Limited.

American Society for Testing Materials

REPORTS AND PAPERS SUBMITTED AT ANNUAL MEETING

Ferro-Alloys

In its report Committee A-9 on Ferro-Alloys submitted nine tentative revisions of existing standards in the form of new tentative specifications which will supersede the existing standards when adopted. These cover: spiegeleisen, ferro-manganese, ferro-silicon, ferro-chromium, ferro-vanadium, molybdenum salts and compounds, ferro-molybdenum, low-carbon ferro-molybdenum, and ferro-tungsten. The new specifications are in closer agreement with commercial practice and requirements, and provide in some instances for additional grades. It is believed that these new standards will be of considerable utility. Additional work on ferro-boron and ferro-titanium and ferro-niobium is under way.

Nickel-Chromium Alloys

Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys recommended the adoption of two existing tentative specifications covering corrosion-resisting chromium steels (A 176) and high-strength chromium-nickel steels (A 177). It was indicated that very satisfactory progress was being made in the collection of data and information covering chemical, physical, mechanical, and fabricating properties of a large number of alloys in this field. These data are to be issued in a special publication by the Society. The committee has set December 1 as the last day for receipt of data, and is asking for co-operation of all concerned. Work is to continue in the development of a recommended procedure for making field corrosion tests, particularly in chemical engineering environments.

Nickel Alloy Steel Castings

Mr. Peter R. Kosting, of Watertown Arsenal, discussed "Surface Cracks on Large 18 per cent. Chromium, 8 per cent. Nickel Alloy Steel Castings." Castings of this material, with large cross-sections, are apt to have intergranular cracks starting at their surfaces and penetrating up to $\frac{3}{8}$ in. As a result of careful studies involving macrostructure and microstructure, the Paper suggested that fine-grain castings will not be prone to such cracking if cooled either quickly or very slowly, and that they may exhibit such cracks if cooled at an intermediate rate. The benefit of quenching such large castings from high temperatures is limited to a very thin skin which may be easily removed during fabrication. In discussing the Paper, R. J. Wilcox, of the Michigan Steel Casting Company, said that while Mr. Kosting indicated that tendency to rupture is dependent on the cooling rate of the casting in the mould and primary grain size of the metal, there appeared to be evidence that the conventional heat-treatment for carbide solution is conducive to surface cracks in large castings, and in several instances large castings apparently free from surface cracks in the as-cast condition indicated small surface checks after quenching in water from 1,065 to 1,120 deg. C.

Chilled Car Wheels

At the session devoted to iron, there were reports of Committee A-2 on Wrought Iron, A-3 on Cast Iron, and Papers dealing with "The Properties and Uses of Chilled Iron," "Hardness Measurements of Very Hard Steels and White Cast Irons," and "Effect of Size and Type of Specimen on the Torsional Properties of Cast Iron." In the first Paper, the author, Mr. S. C. Massari, of the Association of Manufacturers of Chilled Car Wheels, outlined the basic metallurgy of chilled iron, its production and metallographic nature. He pointed out that this material consists in reality of not one, but three kinds of metal: chill proper, with most carbon in the combined state; the mottled iron immediately under the chill, with some free carbon; and the interior of grey iron. While few data are available on tensile properties because of the extreme hardness of chilled iron, he pointed out that the only marked difference in tensile properties between white and grey portions of the same casting was a definitely higher modulus of elasticity in the chill, about 89,000 tons per sq. in. for the white, as compared with about 67,000 tons per sq. in. for the grey. He outlined recent developments in heat-treatment and the effect of some of the generally used alloys, and enumerated a number of important uses, including some 750,000 tons annually for chilled railway truck wheels.

As a result of a large number of hardness tests, including Brinell, scleroscope, Rockwell and Vickers, made on very hard steels and white cast irons, Mr. Vanick and Mr. Eash, of the Development and Research Division, International Nickel Company, Inc., indicated that the discord in relationships emphasises the importance of specifying a type of test which possesses a narrower dispersion from the average in individual tests, such as the Brinell, or specifying a sufficient number of individual tests with other methods, with a tolerance on either side of the average sufficient to encompass the expected spread in values.

Torsion Tests

Tests made on 48 machined specimens from two grades of cast iron were reported in the Paper by Mr. Draffin and Mr. Collins, of the University of Illinois, dealing with the effect of size and type of specimen on the torsional properties of cast iron. This study supplemented the authors' work of last year on the tensile strength of cast iron which involved means of determining accurately tensile properties.

For solid specimens in torsion the modulus of rupture, modulus of elasticity and maximum tensile unit strain were practically the same for diameters of 1 in. and $\frac{3}{4}$ in. For hollow specimens in torsion, having walls $\frac{1}{8}$ in. thick, or a $\frac{t}{r}$ of 0.243, the modulus of rupture decreased from about 39,000 lbs. per sq. in. for the solid specimens to about 27,000 lbs. per sq. in., the latter of which is the strength of the cast iron in direct tension.

For hollow specimens in torsion, the maximum tensile unit strain decreased from about 0.020 in. per inch in the solid ones to 0.0076 in. per inch for a $\frac{t}{r}$ of 0.243, the maximum tensile unit strain in direct tension being about 0.006 in. per inch. The reduction in the tensile unit strain, from that found with a solid specimen to the value found in direct tension tests is reached (by extrapolation) at a value for $\frac{t}{r}$ of 0.15.

Non-Ferrous Metals and Spectography

There were three technical Papers presented, one appended to the Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought, and nine committee reports. A number of these included important recommendations involving standards. The Committee on Spectrographic Analysis announced that it would recommend the publication by the Society of an extensive index to the literature on spectrochemical analysis compiled by Mr. Meggers and Mr. Scribner, of the National Bureau of Standards. This includes a brief introduction, over 900 literature citations and a detailed index covering all important contributions to the literature of spectrochemical analysis since the first development of accurate and reliable methods serving as a basis for commercial inspection of materials. Mr. C. J. Newhaus, International Nickel Company, described "An Arc Source for Quantitative Spectral Analysis." In spectrographic analysis the specimen to be analysed is vaporised in either a flame, arc or spark, the choice depending on a number of conditions. Commenting on the Paper, Mr. H. V. Churchill, Aluminium Company of America, said that despite certain known disadvantages of the arc in quantitative procedures, there were certain fields where it was advantageous, but that the spark sources are far more valuable than arc sources for most spectrographic work. He felt that the Paper was of particular interest because it shows some of the advantages of spectrographic analysis, being simpler than equally precise chemical procedures and far less time consuming. While chemical methods are applicable over wider ranges of composition, the method described by Neuhaus clearly revealed how the spectograph can be applied to routine testing in a limited range of composition.

Corrosion of Non-Ferrous Alloys

Of major importance in the work of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was the report of the sub-committee on atmospheric corrosion. This gave the results of the third series of tests on 24 metals and alloys exposed since 1931 to various atmospheres at nine test locations. There was discussion of change in weight tests, tension tests, visual inspection and information on test atmospheres. While the committee indicated that even a qualitative estimation of the corrodibility of the various materials in the various atmospheres based on only the weight change data is of doubtful value at this time, losses where they have occurred are greatest in the industrial type of atmosphere and most marked in the case of nickel and zinc, whose corrosion products are not particularly protective in this type of atmosphere. The committee indicated that in view of small losses of tensile properties experienced by many of the metals and alloys, it is still too early to attempt rating them on the basis of their corrosion resistance or to predict their probable life in any atmosphere. Certain materials have experienced substantial losses in strength or elongation or both at most of the industrial and seacoast locations. For most of the copper and copper alloys, nickel and high nickel-copper alloys, also lead and lead-antimony alloys, tensile strength losses at all test locations are very small. In rural locations the losses of tensile properties for all materials except tin are negligible.

Committee B-5 on Copper and Copper Alloys, Cast and Wrought, recommended the adoption as standard of existing tentative specifications covering bronze castings for locomotive wearing parts and requirements for lined railway truck and tender journal bearings. A number of revisions in tentative standards were approved and modifications were made in the recommendations covering copper and copper alloy seamless condenser tubes B 111. A recommendation to withdraw the Tentative Specifications for Sand Castings of the alloy: copper, 80 per cent.; tin, 10 per cent.; lead, 10 per cent. (B 74-32 T), was withdrawn and the specification will be continued.

Mr. Catlin and Mr. Mudge, of the International Nickel Company, presented new data on mechanical properties of nickel and some of its high-strength corrosion-resistance alloys, including Monel, Inconel and stainless steels. The authors concluded that tension and torsion impact tests have an advantage over the Izod and Charpy tests, when used on metals of high toughness, because they permit suddenly applied stress to be restricted to a definite area rather than to extend over a large region of the specimen, thereby giving more comparable values.

The usefulness of these alloys for vital parts of equipment is indicated by the properties determined. "A" nickel and the solid-solution, or work-hardening, alloys have true elastic properties in compression, ranging from 15,000 to

83,000 lbs. per sq. in. Similar properties of the age-hardening alloy are from 23,000 to 98,000 lbs. per sq. in.

Light Alloys

Committee B-7 on Light Metals and Alloys, Cast and Wrought, submitted a new method of test for dielectric strength of anodised aluminium. It is indicated that the dielectric strength of an oxide coating can be employed as an approximate measure of its thickness, provided the relation between thickness and dielectric strength has been determined for the specific type of coating under consideration. The committee had developed proposed requirements for aluminium-base alloys in ingot form for die castings, but these were withdrawn and will be considered further. Certain revisions in the standard covering aluminium ingots for remelting were proposed, but action was deferred on the committee's request. Seven of the tentative specifications covering various types of magnesium-base alloy and aluminium-base alloy materials were revised, in some cases by the addition of new alloys which offer desirable characteristics for certain services. Some alloys were withdrawn because of lack of use or for other reasons.

The committee on die-cast metals and alloys offered revisions in certain tentative specifications, but proposed modifications in three of them, involving appended information on the speed of testing, were deleted for further study.

A number of revisions of standards were offered by the committee covering pig lead, phosphor tin, etc., some of the modifications involving chemical composition changes to bring the requirements more in line with commercial practice.

Mr. Foster and Mr. Wilson, Bausch & Lomb Optical Company, described the examination of metals in polarised light, including a description of the way existing microscopes can be corrected to make observations in polarised light. A new polarising vertical illuminator was covered in detail. Applications of polarised light to the identification of copper oxide, copper sulphide, chromic oxide and glassy silicates were illustrated, and also the use of this technique in studies of grain size, preferred orientation and identification of phases in aluminium alloys. Other applications, such as the measurement of anodic coating thickness on aluminium alloys, were described. It is pointed out that only by systematic investigation can the full utility of the polarising microscope be realised in any specific field of investigation.

Radiography Session

The opening Paper by Dr. Lester discussed radiography in industry. He pointed out that radiography is widely used and that not withstanding certain misunderstanding and some incorrect applications in the work, especially in the early years, it has become so important in industry that A.S.T.M., the first technological society to recognise it, has set up a new standing committee devoted to its interests. He pointed out that radiography is not merely a method of testing. It is a device that makes possible the utilisation of more economical methods of fabrication of highly responsible structures, but more important than that, it fills an essential need in industrial evolution in that it makes possible the reasonable assurance of dependable service in the structural units of our modern mechanised society. Up to now, radiography remains as the most generally practical method of non-destructive testing. It is the mandate of Committee E-7 to assist in making this powerful tool most fruitful in its service, not to consumers, nor to producers, but to that epitome of present-day civilisation, industry.

Dr. H. E. Seemann, of the Kodak Research Laboratories, discussed a problem which is very important in radiography, namely, the effect of secondary radiation upon the quality of a radiograph. He also covered the principles of measurement and results of experiments to determine the amount of secondary radiation in the radiography of common industrial materials. Thicknesses were limited to those which can be conveniently radiographed without fluorescent intensifying screens. The principal conclusions to be drawn are: (1) That lead screens may remove nearly one-half of the secondary radiation recorded when no screens are used, and (2) that no important reduction in secondary radiation is possible by adjustments of the kilovoltage within the range it is necessary to use for a given subject. The experiments must be considered as a mere introduction to the study of this important problem in radiography, the author stated, and that further investigation is contemplated with the hope that future results may contribute not only to our knowledge of the subject but to improvements in radiographic technique.

In a Paper on "A Study of Intensifying Screens for Gamma-Ray Radiography" Mr. Briggs and Dr. Gezelius pointed out it has been known for many years that a reduction in exposure time in gamma-ray radiography can be obtained if materials which fluoresce upon exposure to the rays are kept in intimate contact with the film during the exposure. Calcium tungstate has been found to be the most efficient intensified for both X-rays and gamma-rays. However, tests made at the time the original studies on gamma-ray technique were conducted indicated that the calcium-tungstate screens available at that time did not possess enough advantages, when compared to lead screens, to warrant their use.

Since that time there has been considerable improvement in the calcium-tungstate screens available for radiography. It was deemed advisable to study several commercial screens in an attempt to improve the technique now used in gamma-ray radiography. Six different sets of intensifying screens were obtained for the work.

The authors concluded that calcium-tungstate intensifying screens show considerable variations among themselves. Each screen studied had different characteristics. The sensitivity recorded by using the calcium-tungstate screens was inferior to that of the lead-foil screens. Also the longer the exposure the poorer the definition due to the fogging or clouding over of the defects by the fluoroscopic effect retained by the screens.

As calcium-tungstate screens are limited to comparatively short gamma-ray exposures on thin sections, and the wave-length of the gamma-ray makes it unsuitable for use on thin sections, it appears that these screens are at the present time useful only in cases where good sensitivity and contrast are not required.

Symposium of Impact Testing

This symposium was developed by Mr. W. W. Werring, Bell Telephone Laboratories, Chairman of the Section on Impact Testing of Committee E-1 on Methods of Testing, and Prof. M. F. Sayre, of Union College, representing the Welding Research Committee of the Engineering Foundation.

Two sessions were devoted to the symposium. In the afternoon session present fields of commercial use for the impact test were stressed, with particular reference to places where the impact test gives necessary information not supplied by static tests. In the evening session, the basic theory underlying impact testing was under discussion. Intentionally, all discussion of the relative merits of specific specimens of the differing types of impact machines now in use was suppressed in favour of the other two questions mentioned.

Mr. Robert Burns and Mr. W. W. Werring, Bell Telephone Laboratories, reported on the success obtained in reducing the breakage of telephone apparatus, particularly the hand sets, by use of plastics where quality was controlled by impact drop tests on the apparatus parts themselves and on specially moulded test specimens. Success in this testing, however, depended upon careful control of the temperature and humidity at which the specimens were tested, and also upon the use of a combination of several types of test.

Mr. G. C. Riegel and Mr. F. F. Vaughan, Caterpillar Tractor Company, reported upon the success which their company had had in reducing the failures of gears, caterpillar tracks and other parts over a period of years through the development of steels of progressively higher and higher impact strength values, the shape of the parts themselves and the ultimate strength, hardness and ductility of the material used being retained essentially unchanged. The impact test was here used not only as a measure of the resistance of the metal to sudden blows, but also to measure the likelihood of brittle failure under normal static loading at notches or points of stress concentration.

To check the possibilities of added brittleness under severe winter conditions, occasional tests at very low temperatures are made. Occasionally, where ordinary tests leave doubt as to the acceptability of a material, supplementary impact tests on double width specimens with intensified notch effects are made. If the foot-pound values of the double specimens are less than double that of the single width specimens, the heat is not accepted.

The use of varying methods of impact testing, each one devised to meet specific needs, in cases where the ordinary standard methods of impact testing could not be used, was urged by Mr. Sam Tour, of Lucius Pitkin, Inc. He described a number of cases where this has successfully been done.

Mr. W. H. Bruckner described work done at the Naval Research Laboratory at Annapolis on studies of welding properties of steels, in which small test coupons of various steels were given heat-treatments simulating those which occur naturally to the steel immediately adjacent to the line where a weld is being deposited. These coupons were then tested in impact and compared in properties with similar coupons not heat-treated.

In the evening session the outstanding Paper was one by Mr. D. J. McAdam, Jun., and Mr. R. W. Clyne, on "The Theory of Impact Testing: Influence of Temperature, Velocity of Deformation and Form and Size of Specimen on Work of Deformation." This Paper emphasised the fact that notch impact testing was primarily a method of testing for potential brittleness in a material under all types of service rather than a method of testing for resistance to effect of sudden blows, the notch acting to intensify any tendency toward brittleness which might be present in the same way as would lowered temperature or to a lesser degree, higher velocity of blow.

A Paper received from Prof. N. Davidenkov, of Leningrad, U.S.S.R., emphasised that it was often much more important to determine how large a change in conditions would be required to produce sudden increase in brittleness, than it was to know what the ductility or energy absorption was numerically under the test conditions themselves. As a quantitative "brittleness factor" he recommended the use of a ratio obtained by subtracting the temperature at which cold brittleness appears in standard impact tests, from room temperature, and dividing by the room temperature in degrees absolute. This gives an equation identical in form to the familiar Carnot cycle equation, but applied to an altogether different purpose.

A new apparatus by which the momentary stresses and strains could be measured in a test-bar of steel while being suddenly broken in tension was described by Mr. D. S. Clark and Mr. G. Dätwyle, California Institute of Technology, and some experimental results were given, showing that the strength is generally greater than under slow loading with wide variations in the ratio between the energies required to produce rupture under slow and fast loading.

A critical review of literature on impact tests of welds was summarised by Mr. W. Spraragen and Mr. G. E. Claussen, of the Welding Research Committee. Mr. S. L. Hoyt gave an important summary of impact testing developments emphasising particularly our increasing knowledge of the subject.

Effect of Temperature

The Joint Research Committee on Effect of Temperature presented a rather voluminous report outlining results of numerous investigations it is carrying on. One of the projects, which should be of much value to all those concerned with the effect of temperature on metals at high temperatures, is the volume on "Creep Data" which is soon to be published. This gives extensive information and data developed by the committee, covering a wide range of carbon and alloy steels, irons and some non-ferrous metals.

There was a great deal of interest, evidenced by discussion, in the Paper presented by Mr. S. H. Weaver, of the General Electric Company, on "Actual Grain Size Related to Creep Strength of Steels at Elevated Temperatures." The Paper was based on a statistical analysis of 32 creep tests made on S.A.E. No. 4330 steel at a creep temperature of 450 deg. C. The author concluded that there is an optimum grain size for the maximum creep stress and that a larger or smaller grain than this gives decreasing stress for the particular steel and temperature. It was reported that grain size may change the creep strength by 21,000 lbs. per sq. in. and that the structure within the grain can change the creep strength by 4,500 lbs. per sq. in. Several authorities in this field discussed the Paper critically. A number commented on the present situation with regard to grain-size terminology, it not being clear to those in this field when the various authors used the term austenitic size, carbide grain size, actual size, etc. One member indicated that if the specimens of 32 steels had been given the same time and temperature of heating that creep specimens had been given and the austenitic grain sizes determined on them, information on grain size correlation would have been more valuable. Still another authority indicated that while creep stress of a given steel is associated with its grain sizes, mode of distribution of carbides and stability of this distribution during the tests are factors to be considered and other factors may play a rôle.

Prof. J. B. Kommers, University of Wisconsin, discussed "The Effect of Overstressing and Understressing in Fatigue," giving data obtained after the application of various cycles at 10, 20, 30 per cent. over stress. He concluded that the endurance limit of a material is not a fixed quantity, since various methods affect it. Periods of cyclic overstress quite commonly reduce the endurance limit, while periods of progressively increasing cyclic understress may greatly increase the endurance limit.

Lifting Machinery Inspection

The full significance of the Factories Act, 1937, is only just being appreciated, and one of its most important phases is emphasised in a brochure just issued by Herbert Morris, Limited, of Loughborough. It bears the caption "A competent person" and deals with the problem associated with the Act which insists that there must be a regular examination of lifting machinery by a person qualified to warrant such a title. Obviously, the Morris concern, with its 50 years of experience, possesses a large staff of such people, and with the coming into force of this Act on July 1 last they have decided to create a special service for the regular inspection and maintenance. It is well worth the while of our readers to write for details of this service, which are set out in Publication No. 198.

Cupola Charging Hoists

AN AMERICAN INSTALLATION

From a careful examination of average foundry layouts in the light of information that is periodically available respecting the arrangement of the most modern plants, it would appear that the main points where economies are to be obtained are in methods of handling, as would be expected in an industry where it is calculated that anything up to 250 tons of material of various kinds have to be handled per ton of finished product. In particular, efficient mechanisation of the flow from the trucks carrying the raw material to the final charge into the cupola is worthy of special attention when it is borne in mind that there are instances on record of savings of £4,000 being effected in approximately seven months in a large foundry with a 100-120-ton daily melt due to rearrangement on this side. While plants with this rate of production and capable of showing such economies do not come within the ambit of every foundryman's experience, it will be found, however, that in most foundries this portion of the layout is worthy of special study.

Fig. 1 shows a modernised arrangement of a cupola charging installation which replaced an older system employing a locomotive crane for handling the foundry material, which latter was in service for three days each week and required two men on the ground and two men on the crane. Fifteen men were employed in preparing the charges and in charging the three cupolas which were 42 in., 60 in., and 66 in. diameter internally. In addition the cupolas were not giving the best of results owing to insufficient distance between bottom plate and charging sill.

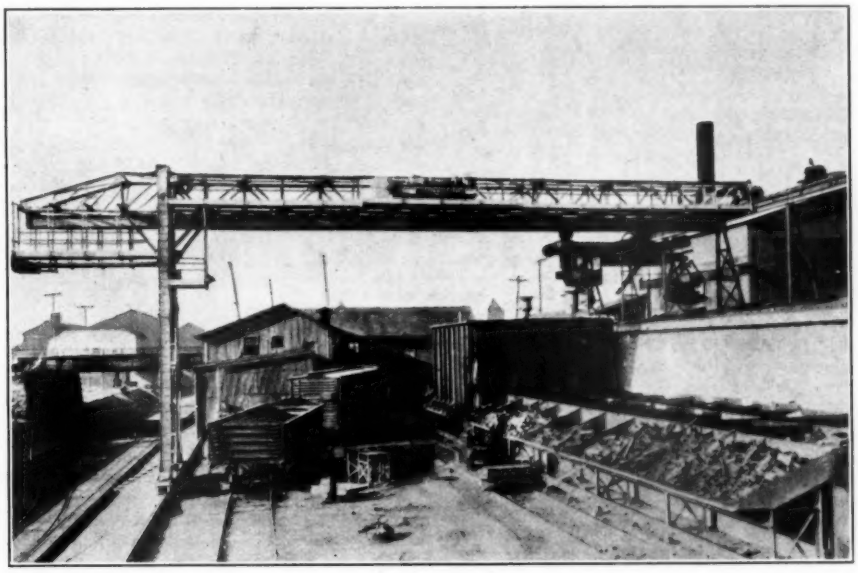

Fig. 1.—One-leg Gantry on which Cupola Charger is Installed.

Fig. 2.—Cupola Charger in Act of Lowering Charged Bucket into Cupola.

The complete modification of this part of the layout involved the following work: Increase in the height of the three cupolas and alterations in cupola house, erection of runways and spur tracks to each cupola; installation of gantry crane and cupola charger; erection of bins; installation of scale car and track; 5-ton single leg gantry crane and 5-ton cupola charger; 4 bottom-dump charging buckets; ¾ cub. yd. bucket; 45-in. lifting magnet; track, and T-bar conductor. The cost of the foregoing was approximately £12,000, but the economies effected amounted to £4,000 per annum.

Under the reorganised arrangement the gantry crane and charger unload all materials from the railway trucks to storage and into the cupola, and in place of the former labour requirements only two men are now required to operate this part of the system.

The type of cupola charger employed is made by the Shepherd Niles Corporation, of Montour Falls, U.S.A. Probably the general construction can be followed more clearly from the photograph of a 5-ton model reproduced in Fig. 2. It will be seen that the use of this type of charger has the effect of removing the men entirely from the charging platform, as the operator in the charger is the only man required, and it is possible by this means for one to four cupolas to be charged by the one hoist when running upon a suitable track with switches. The railway trucks on the siding are unloaded by the same hoist using a magnet for pig-iron and scrap or suitable electric motor bucket for coke, limestone and sand. The cupola charging bucket can be filled with metal charges by using the charging hoist and magnet, or filled from gravity storage bins previously loaded by the charger. With this type, anything in the way of reinforced charging platform is unnecessary, as the operator need never leave the cabin, and roof and protective sides are also not required for the same reason.

Loam Moulding a Special Strainer

It is very fortunate that there still are sufficient special castings, of such a character as is described in this article, required for industrial undertakings. If this were not the case, loam moulders would soon be non-existent. The writer understands that in South Africa the loam moulder* is so scarce that such work must of necessity be done by other means. This often means that the castings cost more and in all probability take longer to produce. But there is not full agreement, however, that such castings when made by loam moulding cost less, and some managements insist on working from patterns in green-sand, or even dry-sand, moulds. It is this class which is exterminating the really skilled loam moulder. This seems a pity, because such moulders will always be required and unless some measure of loam work is to be undertaken and even encouraged it will not be many years before this class of moulder will have disappeared. It is well to remember that long experience is required by the loam moulder, not only in working the loam and bricks, but to understand properly how to work and set up the many strickles required for such jobs.

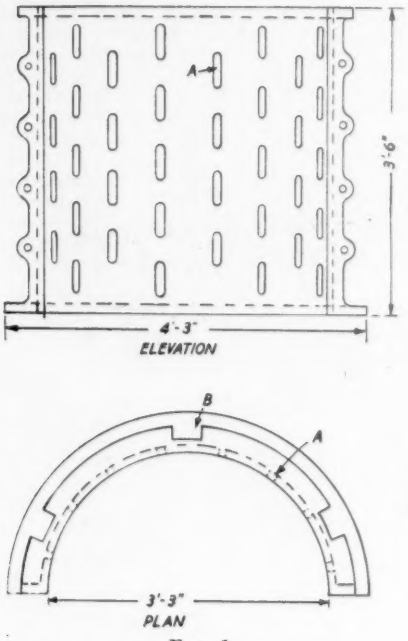

FIG. 1.

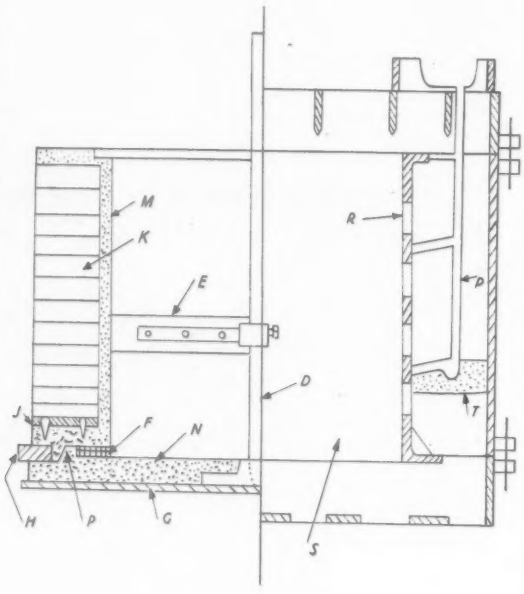

FIG. 2.

FIG. 3.

It is generally agreed that castings made from loam moulds are sounder than those made from green-sand moulds, or even from dry-sand moulds. The reason for this is clear of course, in loam the gases can get away much more easily and quickly, owing to the open nature of the material used; consequently, the risk of scab is practically negligible, blowing almost impossible, whilst the swelling, or castings being out of shape, is considerably reduced. There is also another strong point in favour of loam working, in that it lessens the risk of segregation and shrinkage, due of course to the fact that a loam mould is usually used at a higher temperature than green sand, and therefore there is not that sudden change in temperature when the iron enters the mould.

Fig. 1 shows a plan and elevation of a mould for a strainer casting. It will be noticed that only half a circle is shown, because this strainer had to be made in two halves and each half was bolted together. For ease in moulding and to enable a full sweep of the boards to be made, the two halves were made at the same time and split by a ¼ in. thick mild steel splitting plate. After the casting was fettled it was forced apart, and the splitting plate which was made in a plain strip to enable it to be better secured in the mould, was taken to the acetylene welder and cut to the correct shape, that is to suit the lugs as at "C" and the necessary bolt holes drilled in; the two halves were then bolted together ready to go into the boring mill for machining. The top and bottom flanges had to be machined.

The whole of the mould was strickled up from the spindle, except the side flanges "C," these being made of wood and placed into position whilst the outer portion was being built up. The three slots "B" (Fig. 4) were formed by a dry-sand core nailed into position and marked off true by a wooden former. The slots "A" (Fig. 1) were formed by dry-sand cores and secured to the outer shell by two nails in each. The method of positioning these correctly was by means of a cloth tracing or set out, and lined round the outer casing and nail holes marked through.

Fig. 2 shows a section through the outer casing of the mould, "D" is the spindle, "E" the sweeping board, "G," "H" and "J" are grids to enable the work to be lifted about for drying purposes, etc. "K" is brick work, "M" is the fine loam finish. The bottom base "N" was first struck up in loam on the cast iron plate "G" and dried. The recess "F" which forms the bottom flanges was then filled in with dry floor sand to enable the upper layer of loam and the grid "J" to be placed in position. The purpose of this grid "J" is to hold up that loam which is overhanging the flange "F" and also to support the work above it, whilst this portion was lifted away on ring "H" to be dried, and to enable the centre portion to be struck up. This centre portion was bricked up on the outside leaving the centre portion to be filled up and rammed firmly with black sand. When this centre portion had been finished and dried, the outer halves were placed into position and to assist correct centring the bevel "P" was formed; this was found to be of great assistance. The slot cores "A" were placed on the outer ring, so that the slots on the outside of the casting would be clean and without any flash, whereas on the inside this would not matter so much because of subsequent dressing and was purely on account of appearance. The top box was rammed up on a flat machine-faced table. The runner marked "P" (Fig. 3) was formed as the work was being built up, and the loam block was placed at the base to prevent any risk of tearing up, as shown by "T."

Three ingates were taken into the mould, and this is always good practice as it prevents cold laps, and the like. The finished casting is shown in Fig. 5.

As the work is of a very special character and also only four sets were required the job was rather a long one. It is well to remember, however, never to hurry the moulders unnecessarily on such a job; a few more hours on the work is better than a waster casting. Such jobs can never be tied down to small limits, and it is for the estimating department to remember the nature of the work and the little difficulties which have to be met and overcome, through, may be, lack of suitable boxes. Times must not be cut down, and waster allowance in the estimates should be liberal.

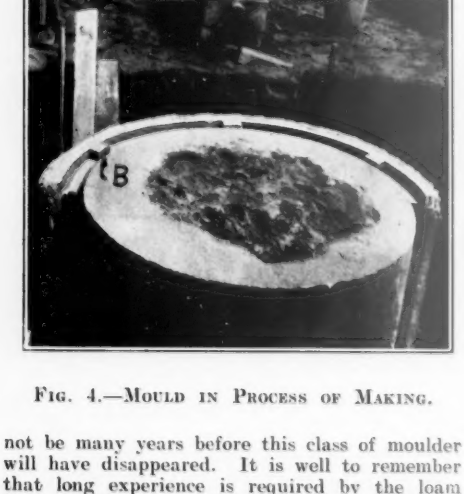

FIG. 4.—MOULD IN PROCESS OF MAKING.

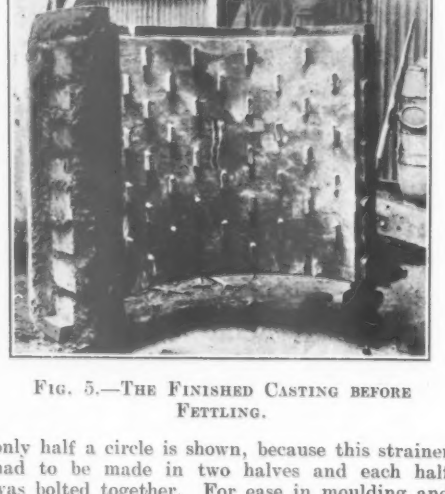

FIG. 5.—THE FINISHED CASTING BEFORE FETTLING.

* The major shortage in South Africa is not of loam moulders but of patternmakers.—EDITOR.

Electric Furnace Pig-iron

The Import Duties Advisory Committee give notice of an application for the addition to the free list of pig-iron produced in an electric furnace and containing not more than 0.025 per cent. by weight of phosphorus, not more than 0.020 per cent. by weight of sulphur, and not more than 2.5 per cent. by weight of total carbon. Any representations which interested parties may desire to make in regard to this application should be addressed in writing to the Secretary, Import Duties Advisory Committee, Shell-Mex House, Strand, London, W.C.2, not later than August 18, 1938.

Copper in Cast Iron

BRADFORD CONFERENCE DISCLOSES INCREASING INTEREST IN ALLOY ADDITIONS

A number of interesting aspects relating to copper in cast iron, such as the work-hardening, limits of usefulness, machinability, and the neutralisation of manufacturing irregularities were brought out during the discussion on Mr. Nicol Smith's Paper presented to the annual meeting of the Institute of British Foundrymen at Bradford. The discussion was opened by MR. J. A. REYNOLDS, who commented that in austenitic cast iron, copper was very useful as a part substitute for nickel, and it behaved in the same way in many respects, but in using high percentages, say, 5 or 5½ per cent. of copper, even with a certain amount of nickel, there was a real danger, especially in machining or grinding thin sections, of "work-hardening," and that must be guarded against.

He had found that the redundant scrap from a crucible nickel-alloy iron which contained copper was very useful as an alloy addition—he would not call it an inoculant—to cupola irons of the Ni-Tensyl type. The copper content was fairly constant, and it was a very desirable constituent in the iron. It did not increase machining difficulties, yet it gave a higher Brinell hardness and certainly a better and more even structure. In the higher-silicon ranges—although the effect was not very observable in the lower-silicon ranges—there was equalisation of structure and a slight softening.

Work-Hardening of Austenitic Irons

MR. A. J. NICOL SMITH, B.Sc., replied that the substitution of copper for nickel was coming to the front; it was difficult to say how far one could go in that direction, but he felt that it could definitely be done to a large extent. As Mr. Reynolds had said, it could be done very satisfactorily in an austenitic iron. The work-hardening properties of Mr. Reynolds' austenitic irons might not be dependent on the presence of copper; irons just above the austenite range often hardened considerably under work.

The results mentioned by Mr. Reynolds concerning the use of the scrap as an alloy addition were such as would be expected, and it was interesting to have confirmation from works practice.

MR. REYNOLDS added that he had experienced the trouble of "work-hardening" when using the usual nickel-manganese austenitic non-magnetic iron. Copper seemed to be on the border line, but he would hesitate to express a definite opinion without making further experiments.

MR. NICOL SMITH said it was quite possible that copper was not quite so effective as nickel in forming austenite, so that when the one was substituted for the other the effect might not be absolutely the same. It might be equivalent to lowering the alloy content and thus increasing the liability to work-hardening.

Copper Additions and Economic Operation

MR. A. J. SHORE asked why copper was used at all. Why, he asked, should we sometimes use a copper-nickel-chrome alloy rather than a nickel-chrome alloy? Was it mainly a matter of economics, was the material improved sometimes by the use of copper, or could the same results be achieved by juggling with the nickel and chrome?

Referring to the copper manganese alloys mentioned by the author, he said he supposed the manganese was added in the cupola, so that the base metal was of a high manganese content.

MR. NICOL SMITH said one could juggle with nickel, copper and chrome and obtain a variety of results, depending on what was required. He agreed the ultimate test was one of economics.

The irons were crucible irons, and both the extra manganese and the copper were added to the ladle.

MR. SHORE asked whether the same improvement in mechanical properties would be achieved if one used high-manganese base metal from the cupola.

MR. NICOL SMITH said he did not see why not; he saw no reason to anticipate any bother.

MR. SHORE said that on occasion he had used an iron containing, roughly, carbon 3.4 per cent., silicon 2.25 per cent., phosphorus 1 per cent. manganese 0.5 per cent. and copper 3 per cent., and he asked what was the outstanding property of that iron, or what was the advantage of the copper there. He had an idea that it improved the resistance to corrosion or initial corrosion. The iron was used in connection with petrol pumps.

Corrosion Resistance

MR. NICOL SMITH could not say much about the effect of copper on the corrosion properties of the iron in which it was used; the results of the corrosion tests he had made were so indefinite as to be of very little use. Apart from the question of corrosion, he suggested that the outstanding property of the iron was that it was capable of being cast into a varied range of sections without developing chill edges on the thin sections or soft places in the thick sections; 3 per cent. of copper in an iron containing 2¼ per cent. silicon and 3.4 per cent. carbon would even up the properties throughout the sections very considerably.

The question as to why one sometimes used copper in iron, at other times copper-chromium and at other times nickel-copper-chromium was to some extent one of economics. Many people maintained that alloying was of no real benefit, because one could nearly always obtain with a straight iron properties similar to those of an alloy. But one did not always want to do that; it was very often far better to add a little alloy than to go to the trouble of running a special mixture. However, the question was really one for foundrymen to answer.

MR. SHORE said he was querying the substitution of copper for nickel rather than the reasons for using all the various alloying materials.

MR. NICOL SMITH said he believed that copper was substituted for nickel for economic reasons mainly. The effects of each of them were somewhat different. For example, copper alone did not tend to produce austenitic or martensitic structures, but it seemed able to help nickel in producing those structures.

Cupola Variations Eliminated

MR. W. B. SALLITT, having congratulated the author on an extremely informative Paper, said that since copper was a graphitiser, it was natural, when adding copper, to reduce the silicon content of the iron to some extent. If this were done, one obtained an appreciable improvement in mechanical properties; whereas by means of simple additions of copper to cast iron, one did not effect much improvement in mechanical properties.

Referring to Table I in the Paper, showing the composition of the experimental bars, he said that in many of the melts there had been an appreciable drop in the carbon content between the first and last test-bar. He suggested that under such conditions chill was apt to be erratic, and he thought due weight should be given to this in any conclusions drawn regarding the effect of copper on chill.

An advantage of using copper was that it seemed to damp out the variation of chill from the cupola during a day's run, a matter of special importance for castings in which the chill had to be controlled very closely. In that connection he mentioned an experience concerning a camshaft, where the chill was controlled so accurately that the cam tips were white (without artificial chills) and the shaft was grey. The effect of reducing the silicon content to about 0.5 per cent. and increasing the copper content to 3 per cent. had been to render the chill of the iron much less subject to fluctuation.

Effect of Copper Dilution

MR. NICOL SMITH said he was inclined to agree that normally, when adding copper to an iron, one would tend to reduce the silicon content to below the original value, since the copper was a graphitiser. But it was very difficult to do that in a research test, and the only way to get at the results was to compare one set with another; it would probably be found then that the combined effect of the reduction of silicon and increase of copper was quite beneficial.

With regard to the losses in total carbon in each of the series of bars of which the compositions were given in Table I, he pointed out that much of that was necessarily due to dilution, since large quantities of copper were added. Undoubtedly, however, some oxidation had taken place. He had never been able to run a cupola all day in order to determine how far the chill varied, but he was glad to have the information given by Mr. Sallitt concerning the damping out of the chill variations.

MR. REYNOLDS asked if the variations of chill referred to by Mr. Sallitt were those due to variations in cupola working.

MR. SALLITT replied that they were.

Shrinkage Properties

MR. A. TIPPER, M.Sc.(Eng.), in thanking the author for his Paper, and the British Cast Iron Research Association for having prosecuted the work, said that all the members of the Institute were definitely helped by such a Paper. Although the Paper and the work described covered a wide range of properties, that work could with advantage be extended.

The effect of copper on structure (dealt with under the heading of micro-structure) had been described and correlated with the physical properties, and was now fairly well established. However, another most important point was the effect on the shrinkage properties of the iron, and in that connection he had in mind particularly, castings of widely varying section. He asked whether the shrinkage tests carried out by Mr. Nicol Smith had given any definite indication that copper was really helpful, for it was known that nickel was helpful in this respect. Copper effected a slight refinement of the graphite and of the pearlitic structure, and seemed to be following the same lines as nickel. Was it right to assume that, if a casting was giving trouble with shrinkage, owing to varying section and difficulty of feeding, the addition of copper would help in the production of sound castings?

Commenting on the references made by a previous speaker to the effect of copper additions when making certain castings which were subjected to pressure, he said this seemed to suggest that the effect of the use of copper was to produce a denser iron, though not necessarily stronger than the porous metal.

Heavy Copper Additions Detrimental

MR. NICOL SMITH said he could not add to the statements he had made in the Paper concerning shrinkage properties of irons containing copper. The test he had used was the Jolley K-test. A difficulty, of course, was that any test used for ascertaining shrinkage properties did not necessarily represent the conditions in any one foundry or any one type of casting; the best that one could do in research was to use a standard test and hope that people would be able to draw conclusions from the results. Using the Jolley K-test, he had found that there was a

definite improvement from the point of view of shrinkage troubles when copper was added to the iron; when 1 per cent. of copper had been added to an iron it had become more sound, less porous and had shown less tendency to sink than was the case without the copper addition. The effect of using a higher percentage copper, however, seemed to be somewhat retrograde. If one added about 2 per cent. of copper, the shrinkage test results were very little different from those obtained with the base iron, and the results obtained when 3 per cent. of copper was added were definitely worse than those obtained with the original base iron, there being more porosity in the centre of the "K" piece and more sinking at the top. At the same time, he felt, in that connection, that there was definitely a linking up of the effects of copper and silicon, that normally the addition of 3 per cent. of copper would enable the foundryman to reduce the silicon content by practically 1 per cent., and the reduction of the silicon content should have a very definite effect on the shrinkage. In other words, if the addition of copper were balanced by the reduction of silicon content, as it would be normally in foundry practice, he did not think the shrinkage effect would show up nearly so much. Under those conditions, he would suggest, up to 2 per cent. of copper would improve the shrinkage conditions.

An Ancient Iron-Copper Arrow-Head

Mr. S. Simpson mentioned, as a matter of interest, an arrow-head, containing copper, which he had had the opportunity of examining some years ago. It dated back to just about the beginning of the Christian era, and had been found by an ecclesiastic who was an archæologist and not a metallurgist, and would not allow it to be chopped up. However, it had been possible to analyse a quantity of about one-tenth of a gramme, and it was found to contain about 5 per cent. of copper; there was also some tin present. Although he (Mr. Simpson) had since dug on the site on which the arrow-head was found, he had been unable to find any more. He suggested that the early foundrymen who had produced the arrow-head had mixed some bronze with some iron; plenty of bronze spears and arrow-heads had been found, but only the one arrow-head made of iron which contained copper.

Mr. Nicol Smith said that that raised the question as to what would happen if there were pieces of bronze or brass in the copper scrap used in iron. He did not think there could be any doubt that the addition of zinc in the form of brass would not be of any great benefit to the iron, and probably one would have to control the chilling properties carefully if there were very much tin present. Apart from that, however, he did not think there should be very much trouble.

Impact and Fatigue Tests

Mr. G. L. Harbach, commenting on the author's reference to the improvement of impact value as the result of the addition of copper, and the point that the Stanton test lay between a fatigue test and a true impact test, asked whether tests had been made on the new machine which gave a single blow, for his opinion was that the results obtained with the single blow were far less erratic than the results of the Stanton test, and that the single blow test was likely to become popular in testing the properties of cast iron.

Another question he asked was whether, in ascertaining the deflections, the plastic were separated from the elastic deflections in cases where high impact values were obtained, and whether the high impact values were associated with a high proportion of plastic deflection.

Mr. Nicol Smith said that the Research Association hoped to say more in the near future concerning the single blow impact test it had recently developed. He had applied the test to some of the copper irons; he had not the results at hand, but, speaking from memory, the results were on the same lines as those of the repeated impact test. Improvement in impact value was obtained with 1 per cent. of copper, and sometimes with 2 per cent., but beyond 2 per cent. of copper the impact values decreased a little, though, so far as he could remember, they did not drop below the value given by the original iron. He had not reported the results of the single blow test in the Paper, because, in the first place, the test was not recognised by anybody but the Research Association at the moment, and, secondly, the test had been applied to only three groups of irons and not to a complete range.

He had not taken note of the plastic deflection as distinct from the elastic deflection. The figures given in the Paper represented simply the total deflections at fracture.

Mr. A. G. Harrison, commenting that the author had indicated the effects of copper additions to crucible-melted and cupola-melted irons, asked whether he had any data on the effect of adding copper in the furnace charge by means of copper scrap or in some other way, because with some of the other alloys there were marked differences in effect according to whether they were incorporated as ladle additions or melted with the charge.

Mr. Nicol Smith replied that he had no data at all of adding copper in any manner other than he had described in the Paper. But he had added copper as a crucible charge (melting it with the iron), and alternatively he had melted the iron first and had added copper just before pouring, but he could find no difference between the results obtained as between the two methods; and he saw no reason to suppose that there would be any great difference.

Catalogue Received

Hydraulic Cleaning of Castings. One of the most interesting of foundry equipment catalogues that has been recently received by us comes from the Hydro-Blast Corporation, of 111, W. Washington Street, Chicago, Ill., U.S.A. Unlike the earlier attempts, this system uses sand and water and then reclaims the sand. Under American conditions such installations are worth while consideration where a firm regularly employs four fettlers. This figure would probably be six under the European condition. It operates at 1,000 lbs. per sq. in., giving a jet speed, it is claimed, of 3 miles a minute! The 25-h.p. Hydro-Blast high-pressure water pump is stated to use less than 30 galls. of new water and 70 lbs. of wet sand per minute. Whilst the catalogue gives much technical and commercial information, the reviewer would have appreciated more details as to cost of water, as he is not at all sure of the amount running to waste. As the expression "new water" is used, it can, we suppose, be assumed that the cost of water would be 30 galls. × 60 × hours worked × cost per gallon as metered out to the foundry. The catalogue is excellently illustrated by diagrams and pictures of the process and castings regularly being handled by the system in the States. We feel reasonably certain that our American friends will send copies of this brochure to our readers on application.

Welsh Aluminium Works

It has been announced by the secretary of the aluminium industry of Neuhausen, Switzerland, that owing to pending negotiations no statement on the plans for establishing an aluminium works in Wales would be made before the middle of this month. At the company's general meeting in April, the chairman announced that an aluminium factory was to be established at Newport and pointed out that the step was rendered necessary by the fact that the company could no longer rely on regular supplies of raw material from France.

Poisonous Gases in Industry

DETECTION OF PRUSSIC ACID VAPOUR

The Department of Scientific and Industrial Research has issued the second of a series of leaflets describing standard methods for the detection of toxic gases in industry. The present leaflet* deals with hydrogen cyanide (prussic acid). Leaflet No. 1, published a short time ago, was concerned with hydrogen sulphide (sulphuretted hydrogen).

Hydrogen cyanide (prussic acid) is manufactured mainly for use in the fumigation of ships and buildings. It is also used to a small extent industrially as a reagent. Further, it is encountered in concentrations which may be dangerous in certain industrial processes—in blast-furnace plants, dyestuffs works, gasworks and coke ovens. The leaflet points out that slight symptoms of poisoning will be noticed after several hours with a concentration of one part by volume in 50,000 while a concentration of one part in 500 will be fatal. It goes on to say "in addition to the danger of the inhalation of hydrogen-cyanide vapour there is a further danger, even to a man equipped with an efficient respirator or other form of breathing apparatus. This danger is the absorption of hydrogen cyanide through the skin, which is still greater if the skin is wet with sweat, owing to the ready solubility of hydrogen cyanide in water. The faint almond-like smell is easily missed and is quite unsuitable as a method of detection."

The method of test adopted consists of drawing a sample of the suspected atmosphere by means of a hand exhausting pump through a piece of specially-prepared test paper. Full instructions for preparing the test paper and for carrying out the test are given in the leaflet. The various reagents which will react to hydrogen cyanide are reviewed, and those recommended are Congo-red-silver nitrate and benzidine-copper-acetate which are capable of detecting concentrations down to one part in 100,000. Test papers treated with these reagents will show characteristic stains, specimens of which are included with the leaflet. Both reactions have been made quantitative and have been developed as standard tests for hydrogen cyanide in industry.

Non-Metallic Inclusions in Steel

Report No. 124 of the chemical sub-committee of the Verein deutscher Eisenhüttenleute, published in the "Archiv für das Eisenhüttenwesen," covers a Paper by P. Klinger and W. Koch on the electrolytic estimation of non-metallic inclusions in steel, and a method for the estimation of silica, alumina, ferrous oxide, manganous oxide, ferrous sulphide and manganese sulphide. The isolation of these non-metallic components takes place in an absolutely neutral solution in a current of constantly replenished electrolyte and with the avoidance of any anodic oxidation. The anode space is not restricted by a collodion bag, while the oxidic residue remains unattacked under the conditions employed. From the residue the carbides and sulphides are removed by suitable solvents. In the portion left containing the oxidic residues, silica, alumina, ferrous oxide and chemically-linked manganous oxide are estimated. By a second separation process the combined sulphur in the steel can be estimated and the free manganous oxide determined. The method has been tested on steels containing 0.01 to 1.2 per cent. C, 0.03 to 1 per cent. Mn, and 0.01 to 1 per cent. Si, and has given good results. Carbides do not interfere with the accuracy of the determination. The results obtained are critically compared with those given by other methods.

* H.M. Stationery Office, York House, Kingsway, London, W.C.2. (Price 5s. 6d. net.)

Relief of Internal Stress in Castings

AGEING, VIBRATION AND HEAT-TREATMENT METHODS DISCUSSED

The joint Paper which MR. BENSON and MR. ALLISON presented to the Bradford Conference dealt with aspects of foundry practice which require still further ventilation. Whilst the authors have maintained their attitude that the essential requirement is heat-treatment, there is apparently a body of opinion which favours either ageing or vibratory treatment.

MR. BENSON, introducing his Paper, said that at the time the experiments were carried out, he and his colleague could not find any work useful for correlation or any real guidance regarding the conditions which were necessary to give effective stress relief in castings, and for this reason they would welcome particularly any criticism or constructive remarks.

Further Correlation of Results Suggested

DR. EVEREST suggested that one should accept the authors' results with caution. There was, on the one hand, plenty of evidence that castings may be stressed locally, even up to breaking point, and such stress resulted in distortion and sometimes fracture long after the casting had cooled. For the elimination of such stress many of the British specifications advised annealing at a temperature of 450 deg. C., but apart from this there was a general impression among engineers that even lower temperatures could be effective, and in fact weathering at normal temperatures was regarded as of use in equalising the stresses in question. Now the authors quoted a figure of 550 deg. C. as the minimum temperature necessary to give stress relief, and this figure was clearly a great deal higher than most foundrymen would be prepared to accept. He asked whether this difficulty had perhaps crept in because the authors were dealing with test specimens where the stress was uniform, whereas the troubles which normally arose in a casting were clearly of a more intense and localised nature. Again, it was obvious that stress relief was achieved by means of creep. Work carried out at the N.P.L. had shown that the creep stress of cast iron at temperatures below 450 deg. C. was relatively low, and certainly far lower than the intense localised stresses referred to above. It would not seem, therefore, necessary to go to a temperature as high as 550 deg. C. in order at least to reduce these stresses to harmless values. It did not perhaps matter a great deal if the stresses left in the casting were low, provided they were well distributed and balanced.

Another point noticed in the authors' Paper was that the work has been carried out on irons of fairly high phosphorus content. It was suggested that this might have had an important bearing, and he asked what the authors would consider the relationship between phosphorus content and the temperature necessary for effective stress annealing.

Stress-Free Castings Non-Existent

MR. BENSON, in reply, said the point raised by Dr. Everest regarding the amount of stress which might safely lie in castings and the annealing temperature which was necessary was a question of degree. It was common knowledge there were many castings in service behaving perfectly satisfactorily which were not stress free. It was probably true to say that there were no castings which were really stress free, and very few which were even effectively stress free. Whilst for some purposes moderate stress could exist without being seriously harmful, there were cases where substantial freedom from stress was desirable and where the slightest distortion would be serious. To obtain a substantially stress free condition, he believed, and all the evidence he had seen supported the view, that that could only be obtained by annealing at about 550 deg. C., followed by sufficiently slow cooling, not to generate a new system of internal stresses.

He thought Dr. Everest meant, when he referred to "uniformity of stress," internal stress of a moderate magnitude.

Specificational Difficulties

There was, of course, no such thing as a casting containing uniformity of internal stress; if the stresses were internal, there must be some stress in tension and some stress in compression. With regard to the specification temperatures, he was glad that point had been raised. The wording of some specifications was misleading. It was stated in some specifications that castings must be annealed at a temperature such as, in one case, 150 deg. C., in another case 350 deg. C., and in some specifications 450 deg. C., for a sufficient time to produce relief of all internal stresses. That, of course, was impossible, unless one annealed at a temperature of 550 deg. C., but at lower temperatures for many types of work satisfactory castings were produced, containing moderate stresses. Referring to Fig. 2, it was obvious that in the region of 400 to 450 deg. C., the rate of stress relief increased very rapidly. He did not think it was possible to obtain any stress relief worth considering by means of ageing. He did not consider that phosphorus had any substantial effect on the annealing temperature, although he had not tried it out experimentally. The relief of stress was really a kind of rapid "creep," and phosphorus was not one of the elements generally recognised as having an appreciable effect on the "creep" behaviour of ferrous metals.

Rigidity of High-P Irons at High Temperatures

MR. R. C. TUCKER pointed out, in reference to the last statement, that the work done by the British Cast Iron Research Association had shown that even at a temperature of 850 deg. C. phosphoric irons were generally more rigid than low phosphorus irons.

MR. BENSON said he did not wish to challenge that statement. He was very glad to have the information.

Ameliorative Effect of Vibration

MR. E. LONGDEN, after congratulating Mr. Allison and Mr. Benson on tackling another phase of foundry practice which was so very important to those who were making delicate and large castings, said so far as the statement was concerned that ageing did not relieve stress, the practical foundryman felt that this did obtain. They put certain classes of castings that could be conveniently handled into ovens for annealing, and found that at a temperature of 250 deg. C. they obtained a considerable change in the dimensional stability of the metal. Castings were usually rough-machined, and then put in the oven for this very slight annealing. He considered that the ageing was in a measure effected by the vibration of the surroundings, rather than just the passage of time. He thought that if one considered the shaking of the casting, the disturbance of it, just by earth tremors due to the operation of a workshop, and temperature changes, that might have a bearing on the question. It was the practice of some foundries to age a casting, and they would not use a casting unless it was twelve months old. Annealing at temperatures round about 500 deg. C. would not injure the hardness, and any serious changes in shape would be cured in 99 per cent. of the cases. But, so far as large castings were concerned, that, of course, was impossible, since such large ovens could not be made available.

MR. BENSON said he was glad to hear that somebody else had found that a temperature as high as 500 deg. C. was advantageous. With regard to ageing, he could not agree that ageing for even a year was going to be beneficial. Yet even if it was, it seemed to be much more satisfactory to produce the effect in a furnace under controlled conditions, and with certainty in a few hours.

Improvement by Rumbling

MR. T. H. TURNER (Doncaster) asked whether the authors had considered the action of rumbling the castings. Some foundries had castings shaken and banged together in a rotating barrel. He had heard that that resulted in a reduction in the residual internal stresses.

MR. BENSON said he doubted whether rumbling would have an appreciably beneficial effect, but he could understand that with small castings containing extremely high internal stresses rumbling might be sufficiently severe to produce local yielding in places. This might occur with steel, but in the case of cast iron such severe treatment would be likely to produce cracking rather than plastic distortion.

Vibration Theory Substantiated

MR. BEN HIRD, speaking with reference to internal stresses in cast iron, said he had definite proof that vibration removed these stresses and improved the strength of the casting. This effect was very pronounced with cast iron railway chairs cast on to steel sleepers. The chairs, when cast on the sleeper, were subjected to a transverse test within a few days of casting. Later a number of these sleepers were taken out of the railway track, after twelve months' service, and tested in the same way. The results showed a 100 per cent. increase in strength. As cast, the average was 20 to 25 tons transverse—after twelve months' service, 40 to 50 tons.

A number of years ago, Moldenke, writing on this subject of vibrations, suggested that large castings which could not be tumbled in a barrel would have their stresses removed and strength improved by subjecting them to vibrations on a plain jolt machine table.

MR. J. H. COOPER said there was a quantity of published data with regard to this vibration of castings, particularly in America, and it was shown definitely that even the tapping of the end of the machine made an increase in the test results which was quite appreciable. It was published in the American Foundrymen's Association's Proceedings, and so much so, that they incorporated in their specification that this should be done.

Cooling Rate Important

MR. KAIN thought members ought to be particularly grateful to the authors for putting this question of stress relief on a quantitative basis at last. There had been much discussion about these matters from time to time, but it had never been previously put on a quantitative basis. He hoped that any further work that they did, they would publish and make available for the steel foundry industry. He asked if the authors could give a definite maximum figure for the cooling rate. He noted that furnace cooling was recommended, but founders were very apt in these days, when pushed for output, to open the doors to hasten the cooling of the castings; shutting the doors to steady-up the cooling, then to re-open them again. He would like to know if they could give a definite maximum figure beyond which they consider it was not safe to go.

Controlling Factors

MR. BENSON, in reply, said that was a very difficult question to answer precisely. He had had experience in the measurement of internal stresses in some castings as delivered to his firm. Also, it was known from general principles that the risk of internal stress was greater with large masses; the greater the dimensions the greater the risk, so that the rate of cooling

(*Concluded on page* 94.)

Cavitation Erosion of Cast Metals and Alloys

By J. W. DONALDSON, D.Sc.

The phenomenon of cavitation, and of the erosion of metals and alloys resulting from it, was first observed in 1894, in propeller blades of destroyers, and since then has been noted more frequently, not only in ships' propellers but also in pump impellers, hydraulic turbines, etc. Cavitation erosion is a type of failure of metallurgical materials in which the roughening of the metal surface has somewhat the appearance of the pitting type of corrosion, but corrosion in which corrosion products are substantially absent. It is a type of failure which has not been exhaustively studied, but, as it is particularly likely to occur in modern high-speed hydraulic machinery of the rotary type, more attention has been paid to it during recent years, and some interesting and valuable information has been obtained.

The theory of cavitation is that, when the relative motion of a liquid and the solid part in contact with it is sufficiently rapid, the pressure may be locally reduced to the boiling point of the liquid at that reduced pressure, and that small bubbles of steam generated at the points of lowest pressure collect and eventually separate from the solid wall, leaving empty spaces in the liquid which are filled with vapour. Rapid condensation of the bubbles, which takes place immediately they are formed, precipitates water on to the walls, and as the pressure jumps from the vapour pressure to a pressure approximating to that which should exist in the absence of cavitation, precipitation occurs at a high speed of liquid impact. This phenomenon not only produces a direct loss of energy, but its erosive effect roughens the solid surface involved, and increases the friction, thus producing a further loss in energy as well as causing the surface to deteriorate rapidly and to exhibit a spongy appearance, which, although somewhat similar, differs from that produced by chemical or electrolytic action. Chemical action in fact plays a very minor part in the cavitation erosion of metals and alloys.

Experimental investigation of the cavitation phenomenon is still in its early stages. Such research work as has been done has either been to investigate the effects of cavitation upon the efficiency or performance of particular units such as propellers, hydraulic turbines or centrifugal pumps, or to determine the destructive effects of cavitation on the materials required for such units. With the first types of investigation the metallurgist or the founder of metals and alloys is not mainly concerned, but with the second type, which deals with the relative rates of erosion of various metals and alloys by cavitation, he is intimately concerned, as the question of finding materials which will withstand cavitation, where it exists and cannot be wholly eliminated, is a very important one to the engineer and other users of metals. The cost of maintaining and repairing large units and the loss of output which occurs while such units are being repaired, renders it essential that suitable erosion-resisting metals be used wherever possible cavitation failures may result.

Types of Cavitation-Erosion Apparatus

Accurate determinations of the relative resistance of metals to cavitation-erosion are difficult, as not only is the rate of erosion slow, but operating conditions also vary considerably. Determinations can be made under more or less controlled conditions in a large scale hydraulic laboratory such as at the Massachusetts Institute of Technology, where the equipment contains over 5 tons of water and erosion effects are produced with runs of 100 hours or more, but such determinations are cumbersome and unsatisfactory and do not allow of the study of either the properties of the solutions relating to cavitation or of the resistance of metals to its attack.

A laboratory method of testing on a small scale consists in passing water at a high velocity through a restricted area, followed by a more or less sudden enlargement, when cavitation action of great intensity is produced. Early apparatus of this type was in the form of a venturi tube, and this is still used to describe such apparatus, although recently more efficient designs have been developed. Another type of apparatus, in which accelerated cavitation-erosion can be carried out on a small scale, is of a vibratory nature in which the metal sample is vibrated at high frequency to produce a very intense local form of cavitation. Although all the variables which occur in practice may not be introduced with either type of apparatus, fairly accurate results can be obtained on the relative resistance of various metals and alloys to cavitation erosion. Both types of apparatus have been used recently by a number of investigators in the United States and Germany, and interesting results have been obtained on cast and wrought ferrous and non-ferrous metals and alloys. In the present review only the results on cast materials will be considered.

TABLE I.—*Cavitation Loss in Plain and Alloy Cast Irons (Mousson).*

No.	Alloy.	Composition.						Tensile strength. Tons per sq. in.	Brinell hardness.	Cavitation loss in 16 hrs. Cub. mm. at 20 deg.C.
		C.	Si.	Mn.	Ni.	Cr.	Cu.			
1	Cast iron	3.18	2.13	0.50	—	—	—	11.0	171	636.0
2	Cast iron with casting skin	3.20	2.00	0.50	—	—	—	11.0	200	396.0
3	Ni-Tensyl	2.54	2.51	0.76	1.05	—	—	24.9	235	376.0
4	5 per cent. Ni ..	2.93	1.36	0.50	4.81	—	—	15.5	303	269.0
5	Ni-Cu	3.10	2.00	1.50	15.0	1.0	7.0	8.0	107	837.0
6	Ni-Cr-Cu	2.77	1.86	1.00	14.48	1.88	6.0	11.0	116	247.0
7	Ni-Cr-Cu	2.95	1.89	1.00	14.36	3.95	6.0	15.5	161	109.0

German Investigations

Many experiments have been carried out during the last five to six years at the Walchensee Power Station in Germany by Schröter on the destruction of materials, both metallic and non-metallic, as the result of cavitation. The original experiments[1] were initiated in order to investigate the damage due to pitting in a diffuser, and the apparatus used for the experiments consisted essentially of a pump which circulated water through a nozzle. Small specimens of bakelite, cast iron and zinc were placed in the nozzle tube and the commencement of erosion on these specimens was noted, and also the position at which the damage occurred.

After the preliminary experiments were completed, further experiments[2] were made using a new form of test nozzle through which water was forced under pressure, and in which two polished specimens of each material under test were inserted in the tube in the form of plates. The apparatus was so designed that commencement of attack was observed under varying conditions with varying velocities of water. The loss in weight of the various specimens was determined, and the influence of surface unevenness on the depth of erosion was also measured with a needle to 1/10 mm. diameter. Aluminium, bakelite, cast iron and lead were examined. In general, so far as the metals are concerned, the results showed that under the experimental conditions of the test, lead was found to erode easily and in a very short time, while to produce the same amount of erosion in cast iron a run of twenty times as long was necessary, as commencement of attack was slow, but when it started, it developed rapidly. Under similar cavitation conditions, aluminium was attacked slowly and uniformly, and showed a loss of weight of less than 50 per cent. when compared with the other two metals.

A further series of cavitation tests were carried out by Schröter,[3] using an improved form of apparatus designed by Walchner, in which cavitation was produced by means of a double weir arrangement. This latter arrangement has two advantages over the venturi profiles, in that it limits the expanse of the cavitation zone and accelerates the pitting conditions, and these advantages are very desirable with regard to the size of the test-piece and the duration of the test run. In this latest apparatus the test specimens were placed opposite the guiding weir and the apparatus was so designed that the commencement of the attack was observed. In determining the resistance to erosion by cavitation of a series of alloy steels, a comparison test was made between a high tensile brass and an 18/8 chromium-nickel steel, when the latter was found to show less than half the erosion of the former after a run of over twice the duration. As regards the steels, a distinct relation was found between their resistance to erosion and their

TABLE II.—*Cavitation Loss on Cast Carbon and Low Alloy Steels (Mousson).*

No.	Composition.						Heat-treatment.	Yield point. Tons per sq. in.	Max. stress. Tons per sq. in.	Brinell hardness.	Cavitation loss in 16 hrs. Cub. mm. at 20 deg.C.
	C.	Si.	Mn.	Ni.	Cr.	Mo.					
10	0.33	—	0.71	—	—	—	Annealed 880 deg. C.	17.4	31.4	159	62.4
11	0.45	0.47	1.51	—	—	—	Quenched 935 deg. C. Tempered 660 deg. C.	38.0	53.5	208	104.0
15	0.30	0.40	0.70	3.0	—	—	As cast	—	—	194	42.1
18	0.27	—	0.75	—	—	0.52	Quenched 925 deg. C. Tempered 675 deg. C.	24.5	38.0	192	73.6
22	0.51	0.48	1.37	—	1.11	0.50	Quenched 935 deg. C. Tempered 650 deg. C.	31.2	46.9	342	36.9
23	0.51	0.48	1.37	—	1.11	0.50	Quenched 935 deg. C. Tempered 540 deg. C.	46.9	89.0	528	11.3
24	0.51	0.48	1.37	—	1.11	0.50	Quenched 935 deg. C. Tempered 420 deg. C.	76.0	111.5	640	4.7

hardness, and it was also shown that the previous treatment to which they had been subjected was also important. A microexamination[4,5] of all the test pieces used in the various experiments confirmed that the damage which occurred to the various metals and alloys by cavitation was due to mechanical action and was not of a corrosive nature.

Another German investigation which might be referred to, although it is not, strictly speaking, an investigation on cavitation erosion, was that carried out by von Schwarz and Mantel[6] on the destruction of metallic alloys by water impact. In the investigation two test pieces, 70 × 15 × 10 mm. and 19 × 16 × 4 mm. respectively, were attached to two radial arms rotating about an axis in such a way that they intercepted repeatedly a jet of water issuing from a nozzle at high pressure, and the repeated impact of the specimens on the jet of water constituted the destructive agency. With this apparatus a first series of tests was made on a number of cast bronzes and cast and extruded brass, and the results obtained showed a relation to exist between the amount of erosion and the Brinell hardness of the alloys. In this series of tests the best results were obtained with an extruded high tensile brass containing 55.9 per cent. copper, 37.0 per cent. zinc, 0.48 per cent. lead, 1.05 per cent. iron, 0.90 per cent. manganese, 1.50 per cent. aluminium, and 3.92 per cent. nickel, a loss in weight of 20 mg. being obtained after an 80-min. exposure. All the other materials showed a similar loss in weight in considerably less time.

In a second series of tests, a high tensile brass containing 55.2 per cent. copper, 38.8 per cent. zinc, 0.35 per cent. lead, 1.09 per cent. iron, 1.8 per cent. manganese, 1.25 per cent. aluminium and 1.73 per cent. nickel, having a Brinell hardness of 116 and 157 in its cast and forged states, showed a much greater resistance to water impact in its worked condition. Tests were also carried out on a cast iron, a cast steel, and on an aluminium bronze containing 10.5 per cent. aluminium and 1.0 per cent. zinc, with Brinell hardnesses of 179, 156 and 106 respectively. The cast iron deteriorated in strength rapidly, the test specimen showing a loss in weight of 80 mg. after a few minutes' exposure, whereas the cast steel did not show much loss in weight for the first 50 min. of the test, after which deterioration was rapid, and a loss in weight equal to that of the cast iron was obtained in 70 min. The aluminium bronze showed little change in the first 90 min. of a 160 min. test, a slight attack up to 140 min., after which attack was rapid.

A microexamination was made of the various test specimens from the different series of tests, and from this examination, from the erosion results, and from general observations, it was concluded that under water impact attack materials with a restricted elastic deformation were broken into fragments, if they were not capable of plastic deformation, otherwise cold-work hardening occurred, until breakdown of the surface set in when the limit of deformation was exceeded. In materials for which the work of elastic deformation was greater, destruction occurred mostly at defects in the structure.

Table III.—*Cavitation Loss on Cast Stainless and High Alloy Steels (Mousson).*

No.	Composition. C.	Si.	Mn.	Ni.	Cr.	Mo.	Heat-treatment.	Yield point. Tons per sq. in.	Max. stress. Tons per sq. in.	Brinell hardness.	Cavitation loss in 16 hrs. Cub. mm. at 20 deg.C.
60	0.06	0.38	0.43	0.17	12.88	—	Quenched 980 deg. C. Tempered 650 deg. C.	26.8	36.6	167	41.0
61	0.06	0.38	0.43	0.17	12.88	—	Quenched 980 deg. C. Tempered 560 deg. C.	34.6	44.2	206	24.6
62	0.06	0.38	0.43	0.17	12.88	—	Quenched 980 deg. C. Tempered 480 deg. C.	39.7	57.1	248	12.0
64	0.10	0.50	0.45	—	17.50	—	Ingot cropping ..	17.8	37.9	201	67.9
67	0.08	0.48	0.49	1.53	12.44	—	Quenched 980 deg. C. Tempered 650 deg. C.	37.1	47.4	232	10.3
68	0.08	0.48	0.49	1.53	12.44	—	Quenched 980 deg. C. Tempered 560 deg. C.	47.4	56.5	281	6.3
69	0.08	0.48	0.49	1.53	12.44	—	Quenched 980 deg. C. Tempered 480 deg. C.	55.8	73.3	363	5.0
70	0.05	—	—	0.05	15.20	—	As cast (sand mould)	—	—	220	113.0
71	0.07	—	—	0.15	15.20	—	As cast (chill mould)	—	—	266	48.9
72	0.06	0.33	0.39	0.98	14.72	—	As cast (sand mould)	—	—	238	85.5
73	0.05	0.35	0.32	1.14	14.48	—	As cast (sand mould)	—	—	302	32.0
74	0.05	0.31	0.36	2.02	14.30	—	As cast (sand mould)	—	—	321	12.9
75	0.07	0.40	0.35	3.36	14.30	—	As cast (sand mould)	—	—	352	9.8
76	0.10	0.33	0.47	0.12	12.88	0.58	Quenched 980 deg. C. Tempered 650 deg. C.	38.3	47.6	223	15.6
77	0.10	0.33	0.47	0.12	12.88	0.58	Quenched 980 deg. C. Tempered 560 deg. C.	43.4	55.2	275	9.5
78	0.10	0.33	0.47	0.12	12.88	0.58	Quenched 980 deg. C. Tempered 480 deg. C.	49.6	66.8	316	7.7
81	0.08	—	—	8.25	18.50	—	Ingot cropping ..	13.4	33.5	145	8.8

American Investigations

The pitting resistance of metals under accelerated cavitation conditions has formed the subject of an extended investigation carried out by Mousson[7] under the auspices of the Safe Harbour Water Power Corporation in the United States. The principal objects of this investigation were to make a standard loss determination of a large variety of metals and alloys in cast, rolled, forged, welded, and sprayed conditions, when exposed to artificially-produced cavitation; to study the nature of the failure and to determine, if possible, those material characteristics, controllable or uncontrollable, influencing the materials: to compare pitting due to cavitation with erosion produced by water jet; and to determine whether the results obtained by the cavitation test could be used as a basis for selecting materials to withstand both types of failure.

The apparatus used for producing the cavitation zones was of the double weir type of design developed by Walchner and used by Schröter.[3] In addition to some minor changes in the weir shapes and orifice dimensions, a major modification was made in the location of the specimens, which were two in number and which were inserted in the parallel side walls opposite each other instead of a single specimen placed opposite the guiding weir. This modification permitted two specimens to be tested at once and was also more desirable, as pitting was found to be more severe in the side walls than at the bottom, while at the same time the specimen in its new position was less subjected to the direct impingement of the fluid which produces impact stresses superimposed on those exerted by cavitation. Test specimens were 4 in. × 1.25 in. × 0.25 in., and a head of water of 480 lbs. per sq. in. with a back pressure of 25 lbs. per sq. in. was used over a run of 16 hrs. duration. The influence of variations in water temperature and air content were also investigated and the former was found to be directly proportional to the vapour pressure and was corrected accordingly, while an air content of more than 1 per cent. was required above the normal air content to reduce pitting to an appreciable amount, and, as the normal variations of air content did not exceed 1 per cent., no correction was made.

The results obtained for many of the cast alloys, both ferrous and non-ferrous, together with their metallurgical data, are given in Tables I. to IV. The cast irons given in Table I can be divided into two groups according to their structure, the first four being essentially ferritic and the last three austenitic. For each group the effect of hardness is clearly indicated, as the cavitation loss decreases consistently with increasing hardness. When the losses of both groups, however, are compared with each other the influence of hardness appears to be overshadowed by the influence of structure, as an austenitic matrix, in which various constituents form a solid solution, appears definitely superior to a ferritic matrix consisting of separate aggregates. The reason for this phenomenon no doubt lies in the cold working properties of austenite.

Table IV.—*Cavitation Loss on Cast Non-Ferrous Alloys.*

No.	Alloy.	Composition. Cu.	Sn.	Zn.	Mn.	Si.	Ni.	Fe.	Pb.	Al.	Mg.	Yield point. Tons per sq. in.	Max. stress. Tons per sq. in.	Brinell hardness.	Cavitation loss in 16 hrs. Cub. mm. at 20 deg. C.
132	Al. bronze	89.0	—	—	—	—	—	1.0	—	10.0	—	15.6	31.2	107	41.6
133	Gunmetal	87.0	8.0	4.0	—	—	0.5	—	—	—	—	8.9	17.8	61	391.0
134	P.M.G. metal	92.43	—	1.81	0.08	3.67	—	0.67	—	—	—	12.5	22.3	111.0	36.8
135	H.T. brass	68.0	—	22.0	4.0	—	—	3.0	—	3.0	—	17.9	37.9	165	43.3
138	H.T. brass*	66.0	—	22.0	4.0	—	—	3.0	—	5.0	—	—	—	161	53.0
139	H.T. brass†	66.0	—	22.0	4.0	—	—	3.0	—	5.0	—	—	—	217	16.0
143	H.T. brass	58.0	—	40.0	2.0	—	—	—	—	—	—	14.7	29.0	114	252.0
145	H.T. brass	55.0	1.5	38.0	3.5	—	—	2.0	0.2	1.5	—	13.4	29.0	129	135.0
146	H.T. brass	56.0	—	36.0	2.0	—	3.0	1.0	—	1.0	—	17.8	35.7	166	80.2
147	Turbadium bronze	50.0	—	44.0	1.75	—	2.0	1.0	—	—	—	15.6	31.3	154	101.0
149	Al. alloy ..	0.04	—	—	—	0.14	—	0.22	—	97.46	2.14	5.4	11.2	49	1,810.0
150	Al. alloy ..	0.08	—	—	—	6.85	—	0.27	—	92.49	0.31	9.8	14.3	74	3,420.0

* Sand cast. † Chill cast.

(To be continued.)

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Sand-Blasting as Applied to the Vitreous Enamelling Process

A DISCUSSION AT BRADFORD

Mr. H. Whitaker's Paper on this subject was presented on behalf of the Institute of Vitreous Enamellers to the Bradford Conference of the Institute of British Foundrymen. It was particularly well received as being definitely objective. As a result, some research work has already been put in hand, and if interesting results are obtained they will be given to the Annual Conference of the Institute of Vitreous Enamellers.

Air Pressures

The discussion was opened by MR. W. TODD (Vice-President, Institute of Vitreous Enamellers), who, commenting on the reference in the Paper to the air pressures used for sand-blasting for vitreous enamelling, it being stated that a pressure of 50 to 55 lbs. per sq. in. at the nozzle appeared to be generally used in this country, although it might fall as low as 30 to 35 lbs. per sq. in., said he was not aware of any vitreous enameller using pressures as low as the latter range for shot-blasting castings nowadays; such pressures were used for ordinary cleaning, but not where vitreous enamelling was concerned. In the old days a pressure of 30 lbs. per sq. in. was used for cleaning castings such as baths and similar sanitary ware to which the dusting process was applied; but even there it was found advantageous to increase the pressure to 40 to 45 lbs. per sq. in.

He suggested that a good deal of space was wasted on the type of rotary tables incorporating a series of circular spaces, as compared with the type of table on which the entire table area was utilised. He supported the author's observations concerning the use of nozzles made of tungsten-carbide and similar alloys.

Plant Selection

Discussing the selection of the most suitable type of plant to use, according to the types of ware produced, he said the percentage of breakages would increase seriously if certain types of castings, particularly those with projecting lugs or sharp corners, were dealt with in the tumbling barrel, and he suggested that in mechanised plants such castings should be dealt with on the slat conveyor or rotary table equipment.

Angular Chilled Grit Preferred

The introduction of the angular chilled iron grit was advantageous not only from the point of view of output, but also from that of the health of the operators; slowly but surely the danger of the operators contracting silicosis had been removed. Some people claimed, however, that the admixture of silica sand to the shot helped to keep the shot clean. He agreed that there was a great deal of room for investigation concerning the cleaning of shot. It was not sufficient merely to pass it through a sieve, either a revolving or a flat sieve; "black specking" was a bugbear to the enameller, and it was important to solve that problem, which was possibly related to blasting.

With a view to reducing wear on the machine due to the blast, a good deal had been done in the direction of using alloy steels; he had obtained good results with a malleable iron blade as against a cast-iron blade or impeller.

Suitable Blast Pressures

MR. WHITAKER replied that for several years he had used successfully an air pressure not exceeding 35 lbs. per sq. in. for blasting castings for vitreous enamelling; although that pressure seemed to produce good results, the pressure used at his works nowadays was nearer 60 lbs. per sq. in. He believed that a pressure of 35 lbs. was sufficient to give the necessary bond for vitreous enamelling, but that pressure did not give anything like the production attained with higher pressures; he agreed that 50 to 60 lbs. was the best pressure for vitreous enamelling. Castings for vitreous enamelling should be able to withstand a pressure of 60 lbs., otherwise there was something wrong with them. It was a very different matter simply to clean castings of, say, malleable iron or other material, on the one hand, and on the other hand to prepare castings for enamelling, for in the latter case there must be a definite pitting of the surface, and a much more thorough cleaning was necessary.

He agreed that a good deal of space appeared to be wasted where the small tables were used in the rotary plant. Obviously, if there were any spaces which were not covered by work, wear would result and maintenance costs would be increased.

He did not consider that the mixing of iron grit and sand was worth while, owing to the large amount of dust arising from the use of the sand. No sand had been used at his works during the last ten years; they had not found the slightest use for sand since grit was introduced.

Table Wear

MR. REYNOLDS said it was the experience in a number of works that the wear on the rotary table plant of the compressor type was very great, and he asked whether the wear on the plant was also excessive where the Wheelabrator type was used.

In the preparation of castings for stove enamelling and galvanising, he was using round shot at a pressure of 25 to 30 lbs. per sq. in. Whilst no doubt angular shot was necessary in order to produce a key on the surface of a casting for vitreous enamelling, he had found that round shot was much better than angular shot for preparing castings for stove enamelling or galvanising, not from the point of view of speed of operation, but from the point of view of wear on the plant, the wear being very small and the results quite satisfactory so far as the finish on the castings was concerned.

MR. WHITAKER said he could not give the experience with regard to wear on the Wheelabrator type of machine table, for he did not think that a table plant had been in use for more than a couple of years or so in this country. But, from his experience of the barrel type of plant, he suggested that the wear on the table plant would be fairly heavy.

The Keying Theory

MR. J. W. GARDOM (Convenor of the I.B.F. Technical Committee, and Vice-President of the Institute of Vitreous Enamellers), commenting upon the author's statement that one of the objects of blasting prior to vitreous enamelling was to roughen the surface and thereby cause a "bond," said there seemed to be a suggestion that, as the result of using grit, small cavities were created into which the enamel would run and become keyed to the metal. He personally could not see it.

Again, he did not think it was true to say that the use of steel grit was universal for blasting and that sand and flint were entirely out of business, and he suggested that, particularly for deep section work, flint was probably better than steel grit from the point of view of the cleanliness of the casting, because there was not quite so much loss of velocity when using flint as when using steel grit; where there was appreciable loss of velocity, the carbon deposit on the casting would not be removed.

In asking Mr. Whitaker to amplify his remarks concerning the striking of a balance between the hardness and toughness of the grit used, he said he did not think that the toughness entered into the problem, but that it was hardness that mattered. He felt that the more the grit could be made to break up, the better was the keying, and it was economical to throw the material away as soon as it was used.

As to the suggestion that pressure apparatus might be made more robust and more accessible, he said that always the plant manufacturers were told that their plants were not good enough; it would be well if buyers would remember that it cost money to make a plant good enough.

Types and Sizes of Grit

Dealing with a suggestion that users were tied to the use of only two types of grit, he said there were plenty of other types, and perhaps the reference was to two sizes.

MR. WHITAKER said he had referred to two grades. The sizes he used were 14's and 16's.

MR. GARDOM repeated that there were plenty of others available, and, if Mr. Whitaker had tried them, he would like to know the results. He also asked for a rough figure representing the cost of sand-blasting castings for vitreous enamelling, or the proportion represented by sand-blasting in the total cost of vitreous enamelling.

As to Mr. Whitaker's statement that he had used successfully air pressures down to 35 lbs. per sq. in., he asked whether the size of grit used was varied with the air pressure or whether the 14's and 16's were used indiscriminately, or whether allowance was made for the fact that much of the grit was broken up so that he was not actually using 14's and 16's when the air pressure was 35 lbs.

In a reference to the "bogey" of waste space on the rotary table, he said he could not appreciate the argument. The whole idea of any conveyor was to get certain work past a certain spot in a certain time, within which time the work was to be done; if the work were not coming out completely finished, the table was slowed down, whereas if it were coming out too well—which was impossible from the point of view of the founder—the table was speeded up. So that it was merely a question of time.

Continental Preference for Round Shot

On the Continent recently he had visited a vitreous enamelling plant where round shot was used for sand-blasting, with extremely good results. There seemed to be a definite change-over to round shot there; therefore, he asked whether Mr. Whitaker had had experience of its use, and particularly, what results were achieved

with the different sizes of round shot on castings for vitreous enamelling.

Even though Mr. Whitaker had said that there were only two sizes of shot, it would be interesting to know which of the two he had found to give the better results.

A Key Bond Essential

MR. WHITAKER, dealing with the criticism of the statement that one of the purposes of blasting was to roughen the surface and thereby create a " bond " between the enamel and metal, said he was under the impression that a bond was necessary, that there must be small dendrites or " fingers " of enamel which provided mechanical adhesion between the enamel and the iron. It could easily be confirmed by trying to enamel castings which had not been sand-blasted; if one used even perfectly clean castings which had not a bond, one would quickly experience trouble. Not only was a bond necessary for cast iron, but also for steel sheets, and he believed that was one of the reasons for pickling.

Use of Flint

With regard to grit *versus* flint, he had mentioned in the Paper that the use of flint was still advocated for certain purposes. For example, he had heard that it was used by people who were enamelling large tanks because, if any of the abrasive were left inside, it was better that that abrasive should be flint rather than steel grit. His works, however, were producing a large quantity of hollow articles, and they did not intend to go back to the use of flint.

He had expected criticism of his reference to " striking a balance " between the hardness and toughness of the abrasive, but he did not think that the user of grit wanted it to break up immediately it was put to use. That breaking up might be good for the grit suppliers, but not for the users, who wanted it to give a certain life; if it were to break up to dust immediately it was applied, the users would experience considerable trouble. He was not quite sure if " toughness " was the correct word to use, and how it was related to the tensile or the crushing strength, but he wanted grit which would stand up to the blow without immediately disintegrating into dust.

It was true that the robustness and strength which could be achieved in a plant must depend on cost, and it would not be fair to beat down suppliers in price and still expect them to produce very strong plant.

Restriction of Sizes Problem

The grades of grit in common use in the vitreous enamelling industry were 14's and 16's, which two sizes represented, he estimated, about 90 per cent. of the total amount used in the industry. How far the 14's and 16's were used in order to follow the fashion and how far they were used because they were considered the best sizes, he could not say, and that was why he had suggested that either the British Cast Iron Research Association or the National Physical Laboratory or some other body should carry out fundamental research on sand-blasting, using the various grades of grit. He suggested that the investigators might start with 1 sq. ft. of iron or steel of uniform composition, using a long-life nozzle, and constant air pressure, blast for a certain length of time, and ascertain how much was removed. He believed the Germans had carried out research on those lines, but he was not aware that such work had been done in this country.

He believed a large firm of stove makers had tried different sizes of grit and had concluded that the 14's and 16's were the best.

He would prefer to avoid the question of costs for obvious reasons, but sand-blasting represented one of the major items of cost in vitreous enamelling, and he could give Mr. Gardom some information on that point privately. When working at a pressure of 35 lbs. per sq. in. he had used the same grade of grit as he was using at present at the higher pressure.

He had had no experience of the rotary table as applied to the airless type of plant; but it was true of all types of blasting plant that blasting parts of the plant rather than the goods was an expensive matter. With regard to round shot, he had always been under the impression that it had merely a peening action and did not give the " bite " into the surface of the metal which, he contended, was required for vitreous enamelling.

Pickling Proposed

MR. J. J. MCCLELLAND commented on the statement in the Paper that no other method of cleaning had been found so effective as blasting for cast iron which was intended for vitreous enamelling, and asked whether there was any objection, other than that of cost, to the use of the pickling process, which was applied to castings for galvanising, tinning, etc., in order to ensure that the surfaces were sufficiently clean to enable the coatings to adhere.

MR. WHITAKER said he was often asked for advice as to the preparation of castings prior to blasting, and it was generally sufficient to give them a good fettling and to grind off any " knobs and excrescences," but it was not necessary to grind all over. When enamellers asked for castings with a smooth skin they did not mean dead smooth, as obviously blasting would roughen such a surface, but a clean surface, as free as possible from sand, etc. He did not think the pickling of castings prior to enamelling was a practical proposition. He was aware that it was applied to sheet steel; but he believed it was not applied to cast iron because the latter might be porous, so that acid might soak in and salts would form and give trouble later in the enamelling process.

I.V.E. RESEARCH OFFICER

DR. G. T. O. MARTIN.

Dr. Martin, whose appointment by The Institute of Vitreous Enamellers as research officer was announced in the Journal last month, studied at London University for B.Sc. and Ph.D. degrees in chemistry. He is joint author of several Papers in the " Journal of the Chemical Society " on research work carried out for the latter degree. He was engaged in the works research laboratory of the Mond Nickel Company's works at Clydach, and then joined the British Cast Iron Research Association as enamelling investigator before receiving his present appointment.

Control in Grit Manufacture

MR. J. H. COOPER suggested that the reason why shot was sometimes broken into smaller pieces immediately it was used was that the makers produced it from a quality of metal which was entirely unsuitable, in order to reduce their costs. If they used metal containing more than, say, 2½ per cent. of silicon—which was present in many machinery castings—and made shot in the usual way, by allowing the metal to trickle down a lander, blow it with a steam jet to fall into a tank of water and then take the large particles through a sieve and a crusher, it would not be suitable, as it would be composed practically, not of chilled white iron, but of iron which was grey and sometimes even contained graphite. Thus the user, instead of roughening the surface of his casting, would be defeating his object by covering the surface with graphite, which he had seen in some of the larger pieces of shot which he had broken and examined. He asked whether some of the black spots which appeared regularly on enamel could be the result of applying a deposit to the surface of the casting instead of cleaning it.

MR. WHITAKER said he did not think that was a very vital matter; he had watched the production of shot very carefully, and did not think that very much grey iron got through.

MR. COOPER pointed out that the depth of chill or hardness in any metal was determined by the composition of the metal; that applied to small or large particles, without exception. If one used a metal having less than or more than a certain range of silicon, a 1-in. or ⅞-in. test-bar or shot would show no chill, but simply a blackening. Various irons were used in the cupola, and sometimes a small proportion of steel scrap was used. Without wishing to suggest that the German practice was better than British—indeed, he believed the reverse was the truth—he said the tendency in Germany was to use more round shot, because they exercised more care in the selection of their raw materials, and they tested the shot by hammering it on an anvil; it would not fly to pieces on impact unless it was almost grey.

MR. V. C. FAULKNER (Past-President), who presided, suggested that the adhesion of enamel to iron might be regarded as due to a chemical reaction between the enamel and the iron. Sand-blasting increased the surface area of the casting, and so provided a better opportunity for the chemical reactions to take place.

On the motion of MR. F. J. COOK (Past-President), seconded by MR. D. SHARPE, a hearty vote of thanks was accorded the authors of the various Papers presented to the conference, and tribute was paid particularly to the authors of Exchange Papers from overseas.

World Power Conference

Preliminary information received from the British National Committee of the World Power Conference indicates the probability of a record attendance from this country at any Sectional Meeting held abroad at the meeting which is to take place in Vienna from August 25 to September 2. The party is likely to number about eighty, and to include many well-known engineers, industrialists and men of science. Amongst those who have already arranged to be present are Sir Harold Hartley, F.R.S., who is chairman of the International Executive Council and of the British National Committee, and whose work as chairman of the Institute of Vitreous Enamellers is well known; Sir Archibald Page, the chairman; and Mr. Harold Hobson, the general manager of the Central Electricity Board; Mr. J. M. Kennedy, deputy-chairman of the Electricity Commission; Mr. F. M. Birks, deputy chief engineer of the Gas Light & Coke Company; Dr. F. S. Sinatt, F.R.S., Director of Fuel Research, D.S.I.R.; Mr. Charles H. Merz, of Merz & McLellan; Dr. H. F. Gillbe, of the Ministry of Transport; and Mr. G. H. Nelson, chairman and managing director of the English Electric Company, Limited. It is important that completed membership applications should be sent at the earliest possible date to the British National Committee, World Power Conference, 36, Kingsway, London, W.C.2.

Alternative Itinerary for American Tour

As some members of The Institute of Vitreous Enamellers have expressed a preference for train journeys instead of travelling by air during the forthcoming trip to the U.S.A., the Committee has prepared the following alternative itinerary.

October 1.—Leave Southampton in m.s. "Georgic."

October 2.—Call Cobh (Queenstown).

October 8.—Due New York and stay at the Hotel Waldorf-Astoria. (Surplus luggage can be left here and collected on return to hotel on October 19.)

October 9.—Free in New York.

October 10.—Leave New York (Pennsylvania Station) at 12.50 a.m. (Sleepers open from 9.15 p.m. on October 9.) Due Baltimore, 5.39 a.m. (Sleepers may be occupied till 8.00 a.m.) Reception by P.E.I. Committee and tour through:

(*a*) Porcelain Enamelling & Manufacturing Company (makers of Pemco frit).

(*b*) Baltimore Enamelling & Novelty Company (a large sign plant).

(*c*) Locke Insulator Company (mills and equipment manufacturers).

(*d*) Standard Sanitary Manufacturing Company (sanitary ware).

Leave for Pittsburgh, 9.49 p.m. from Camden Station.

October 11.—Due Pittsburgh, 7.40 a.m. Visit Carnegie-Illinois Steel Company's plant (largest steelworks in U.S.A.); visit Ingram-Richardson Manufacturing Company at Beaver Falls (largest table-top manufacturers in the east).

October 12.—Leave Pittsburgh 1.35 a.m. for Dayton. Due Dayton 7.07 a.m. Visit Frigidare Corporation's plant (refrigerators) and the Armco plant at Middletown. Leave at 8.55 p.m. Penna R.R.

October 13.—Due St. Louis 5.00 a.m. (sleepers may be occupied till 7.30 a.m.); thence Wabash R.R. 8.58 a.m., due Urbana (Ill.) 1.10 p.m.

October 14.—Attend Porcelain Enamel Institute's third annual forum and banquet. Leave Urbana 12.00 midnight, Illinois Central R.R.

October 15.—Due Chicago 4.00 a.m. (Palmer House Hotel.) Sight-seeing in Chicago and visit Chicago Vitreous Enamel Product Company (frit makers), Edison G.E. plant, and Roper Gas Stove Company.

October 16.—Leave Chicago (Grand Central Station) 11.30 p.m.

October 17.—Due Muskegon 7.30 a.m. Visit Norge Refrigerator plant. Leave for Detroit at 12.01 p.m., due Detroit 5.00 p.m. Visit Ford Motor Company or Detroit Gas Stove Company. Briggs Bodies (sanitary ware). Stay night at Hotel Book-Cadillac.

October 18.—Leave 8.00 a.m. for Cleveland, arriving 12.08 p.m. Reception by Porcelain Enamel Institute's Committee. Visit to Ferro Enamel Corporation and other enamelling plants. Leave for New York 8.45 p.m.

October 19.—Due New York 8.20 a.m. Sail at noon by s.s. "Washington."

October 26.—Due Southampton.

About 15 members have signified their intention to participate in the tour.

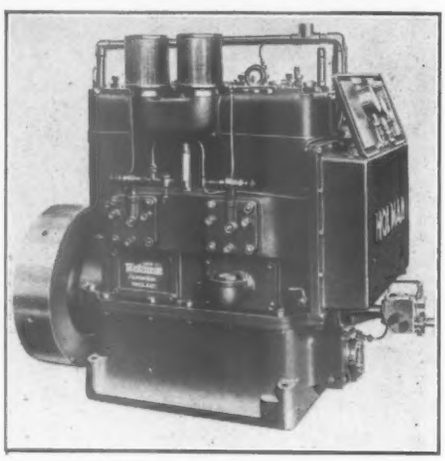
C. A. PARSONS & COMPANY, LIMITED, Heaton, Newcastle-upon-Tyne, have received an order from the Birmingham City Council, valued at £215,000, for the supply of a second turbo-alternator and condensing plant. A. Reyrolle & Company, Limited, Hebburn, has successfully tendered at £92,101 for the supply of main switchgear for the second 53,500-kw. turbo-alternator.

The Holman Two-Stage Air Compressor

The accompanying illustration shows the Holman two-stage air compressor, Model "T.60.S," as built by Holman Bros., Limited, of Camborne. It is designed for a displacement of 612 cub. ft. per min. and pressures up to 150 lbs. per sq. in. The design and construction enable the compressor to be run with high efficiency up to speeds of 720 r.p.m.; for its weight and size the output is therefore exceptionally large.

The diameters of the pistons are 12 in. and 9 in. with a piston stroke of 6½ in. The dimensions of the unit are as follow: Overall length 5 ft. 1½ in., width 3 ft., height 4 ft. 7 in. The first stage of compression takes place in the upper end of each cylinder, and the second stage in the annular space surrounding the reduced lower portion of the two-diameter piston.

Effective intercooling is provided by passing the air through gilled tubes of three intercooler



HOLMAN "T.60.S" TWO-STAGE AIR-COMPRESSOR.

elements which, secured to the cylinder, are enclosed by a rectangular cover. Water is first circulated through the intercooler, and from thence passes through the jackets of the cylinder and cylinder cover. The valves of the multi-port disc type are retained in their respective chambers by means of lantern rings. Unloading is effected by holding open the low-pressure and high-pressure suction valves. A separate pilot is provided for each cylinder to give step unloading.

The bearings are lubricated under pressure from a pump, whilst the upper cylinders are supplied with oil from a sight-feed lubricator. The fittings include an air filter at the inlet, thermometers at the inlet and outlet of the intercooler and also at the final delivery outlet.

A safety valve is fitted on the delivery passage from the low-pressure cylinder.

Aveling-Barford, Limited

MR. EDWARD BARFORD, chairman, in his speech at the annual meeting of Aveling-Barford, Limited, held on July 19, stated that the principal products of the company now included road rollers, Diesel, petrol and steam driven, for all classes and conditions of work; modern, large-scale cooking apparatus; decontaminators for air-raid precautions schemes; also dairy machinery. A recent development was the Aveling dumper, which is used in connection with excavation for earth moving. Orders to date during the current year showed further increase. The chairman emphasised the difficulties of export trade, principally due to subsidised German competition. He pointed out that the unique bargaining power possessed by this country as the greatest importing nation *per capita* could, and should, be used to secure more reciprocal trade.

Silicosis Dangers in Frit Making

The danger to workers engaged in the preparation of raw materials for frits is chiefly centred in the use of finely ground quartz, as has been frequently pointed out, and further emphasised by Dr. Middleton's recent Paper* before the Ceramic Society. In that Paper it was pointed out that removal of the dangerous dust at its source was at the most only a partial remedy, and that the best method must always be the substitution of a non-injurious material for the dangerous one where at all possible. In this connection, the use of alumina powder for flint in the biscuiting of china is a step which appears to have good prospects of success.

The question therefore arises as to whether any other form of silica is available for the frit makers which can be used without detriment to their product, and the only possible one appears to be fine sand of the quality of that derived from Fontainebleau, which, by the way, is virtually free from iron. One firm has been progressively eliminating quartz from frits in the last two years and substituting this sand.

It will be obvious, of course, that since pure sand free from iron has no more objectionable colouring matter in it than has an average good quality quartz, and is almost wholly silica, the difficulties, if any, can only be mechanical ones, arising from the greater apparent specific gravity of the sand. The difficulty, such as it is, consists in the diminished speed with which the sand is taken up by the basic constituents of the frit, but in the case of clear frits and coloured ones this is of no importance, since a little longer time in the frit kiln is of no detriment to the frits themselves—the difference is of the order of 10 per cent. extra time in firing.

These frits in use behave in exactly the same way as the same frits when quartz replaces the sand, and this result is to be expected. The matter of opaque frits seemed somewhat difficult, and this subject is being investigated, but up to now it appears clear that much the same conditions as detailed above apply to white frits, although the extra time might have been expected to reduce the opacity which is being sought. The Home Office attaches great importance to this substitution, for the reason that this natural sand has almost complete freedom from the extremely fine dust which is the essential danger of ground quartz, and in general interests the substitution is worth trying out by all the various frit manufacturers.

Sir Nowroji Saklatvala

Sir Nowroji Saklatvala, K.B.E., C.I.E., chairman of Tata, Limited, died suddenly at Aix-les-Bains on Thursday, July 21, at the age of 62. Educated at St. Xavier's College, Bombay, he was later associated with Sir Dorabji and Sir Ratan Tata, sons of Jamsetji N. Tata, the famous industrial pioneer, in the development stages of the iron and steel industry in India. In 1932, on the death of Sir Dorabji, he succeeded him as chairman of Tata, Limited, which embraces textile, iron and steel, hydro-electric, cement, oil and aviation interests. Our readers will best remember Sir Nowroji Saklatvala as chairman of the Tata Iron & Steel Company, Limited. This great concern, it will be recalled, has its works at Jamshedpur, Bengal, including coke ovens, blast furnaces, steelworks, and rolling mills, making a wide range of finished products. Under Sir Nowroji's direction these important works have played a leading part in industrial development in India. He was appointed C.I.E. in 1923 and knighted in 1933, being made K.B.E. at the beginning of 1937. In 1921 he was at Geneva as employers' delegate from India. The funeral took place last Monday in the Parsi burial ground at Brookwood Cemetery.

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* Journal Ceramic Soc., May, 1938, Vol. XXXVII, No. 5.

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B 5

The Week's News in Brief

Trade Talk

Reduction of the capital of the Glanmor Foundry Company, Limited, from £100,000 to £70,000 has been confirmed.

The 25,600-ton battleship "Grosser Kufurst," towed keel uppermost, began its journey on Sunday from the Lyness depôt of Metal Industries, Limited, to the yard at Rosyth, where it is to be broken up.

A keep-fit campaign has been introduced by the Harland Engineering Company, Limited, Alloa. All employees under 21 can, if they wish, participate in physical training during working hours, one hour a week being allowed for each employee. An experienced instructor is in charge of the classes.

Qualcast, Limited, of Derby, have secured control of Follows & Bate, Limited, Gorton, Manchester, and the two concerns are to be amalgamated. The new arrangement will make this the largest firm of lawnmower manufacturers in the world. Extension of the Victory Road works at Derby is foreshadowed.

A general meeting of Anti Attrition Metal Company, Limited, will be held at Glengall Works, Glengall Road, London, S.E.15, on Tuesday, August 30, at noon for the purpose of having an account laid before the members showing the manner in which the winding-up has been conducted and the property of the company disposed of, etc.

The Walsall Chamber of Commerce received a report last week that the question of the importation of subsidised German castings and the effect on local manufacturers had been taken up with the Import Duties Advisory Committee. In response to the Committee's request information was being compiled as to the cost of production of the castings and the difference in price between the home and the imported articles.

The "Robert Dundas," a vessel specially built to deal with Admiralty stores and well equipped with cargo handling arrangements, was launched from the slipway of the Grangemouth Dockyard Company, Limited, on July 28. She is 219 ft. long, with propelling machinery of the Atlas Polar Diesel type, supplied by British Auxiliaries, Limited, Glasgow. A sister ship, the "Robert Middleton," was launched last month, and is at present being fitted out at Grangemouth.

The Appleby-Frodingham Steel Company, Limited, has ordered five Ruston-Bucyrus excavators for use in their ironstone mines at Scunthorpe and South Lincolnshire. Three of these machines are required for opening up and developing new ironstone properties at Scunthorpe. The remaining two machines are for their Cottesmore mines. Other recent orders received by Ruston-Bucyrus, Limited, for the ironstone fields include a 100-RB Ward-Leonard electric dragline and a 43-B Diesel dragline for Stanton Ironworks Company, Limited.

Aluminium, Limited, the large Canadian producers of aluminium, and the British Aluminium Company, Limited, have formed joint plans for the production and rolling of aluminium in India. Companies will be registered in India in the near future, having a total capital of approximately twelve million rupees (£900,000). It is believed that substantial participation in both capital and management will be offered to Indian interests, and that the aim and ideal is to establish a really national Indian industry.

Relief of Internal Stress in Castings

(*Concluded from page* 87.)

to be preferred depended not only on the shape of the casting, but on its mass, which complicated matters very profoundly. There was no doubt that many small castings, particularly when uniform in shape, were in a perfectly safe condition if air-cooled from the annealed temperature. At the other extreme, very large castings developed internal stresses so easily that people who had had experience of these knew of castings cracking spontaneously on cooling down freely in air. For example, rigid barrel-shape castings must be cooled very slowly in the furnace. The largest castings of which he had had personal experience, such as flywheels of 20 to 50 tons weight as rough-machined, must be cooled down in the furnace for a period of days, say for a week, if they were to be substantially stress free. With the intermediate size of castings he feared one had to be guided by experience. At Trafford Park steel castings for turbine work were all cooled slowly in the furnace, particularly on the second anneal which was at 600 to 650 deg. C. The most dangerous range of temperature was the range during which the castings changed from a plastic condition to a rigid elastic state. That range was known for carbon steel, and it was also substantially the same, he thought, for cast iron. That range of temperature was from about 600 to 350 deg. C.

Mr. Makemson, in closing the discussion, said that further contributions to the discussion in writing would be welcomed, and would be published.

Personal

General Sir J. F. Noel Birch is retiring from the Board of Vickers, Limited.

Mr. A. J. Peech has been appointed secretary of the Stanton Ironworks Company, Limited, and its associated companies as from August 1.

Capt. F. D. Simpson, managing director and deputy chairman of Darlington & Simpson Rolling Mills, Limited, has been appointed technical director of the company. Mr. J. W. Harrison, the general manager, has been appointed the new managing director.

Dr. F. O. Clements (technical director of the research laboratories of General Motors Corporation, Detroit), Dr. W. K. Hatt (Research Professor, Purdue University, Lafayette, Ind.), and Mr. H. F. Moore (Professor of Engineering Materials, University of Illinois, Urbana, Ill.), have been awarded honorary membership of the American Society for Testing Materials.

Mr. Ernest R. Troughton, vice-chairman of the International Diatomite Company, Limited, and of its subsidiary, Moler Products, Limited, has been appointed chairman of both companies. Mr. F. H. X. Gwynne, managing director of Moler Products, Limited, has joined the board of the International Diatomite Company. The boards of the two companies are now the same.

Obituary

Mr. John Ballantine died on July 25 at the age of 65. He was late manager of the Phœnix Works of Stewarts and Lloyds, Limited, Rutherglen. He was responsible for the laying down of the company's new tube-making plant at Newcastle, New South Wales.

Mr. Peter Allan, J.P., of "Keswick," Carron, who died on Sunday last in his 80th year while on holiday at Inverness, retired from the service of Carron Company in May of this year after having been employed for the long period of 65 years. Mr. Allan entered the company's service as an apprentice patternmaker, and for many years had control of the department. When Mr. Allan began his apprenticeship the wage was 4s. 8d. per week, and he could recall the time when the workmen went to their day's labour dressed in "tile" hats and frock coats.

W. Edwards & Company, of Vaughan Road, Loughboro' Junction, London, S.E.5, in announcing that they have been appointed the British representatives for Stokes high-vacuum pumps, have sent us a well-illustrated brochure detailing the special features of this new line.

Company Meeting

W. & T. Avery, Limited

The ordinary general meeting of W. & T. Avery, Limited, was held last week in Birmingham. Sir J. Fortescue Flannery, chairman, who presided, said that considerable progress had been made during the year in design, methods, and improved manufacturing resources. Weighing, counting and testing operations were so closely woven into the fabric of industrial organisation that in their designs not only had they to keep abreast of the movement in all classes of manufacture, but often they had to anticipate the tendencies of plant and process development in various trades. Their associated companies in South Africa, in Australia, in New Zealand, their branches in India and other parts of the Empire had all shown progress. While he found it difficult to prophesy, the situation was a delicate one, increased costs had to be borne, and industry could be subjected to many happenings outside their control. Their company was better equipped to-day to meet any situation that might arise than at any time in its history.

Company Reports

Glacier Metal Company, Limited.—Half-yearly dividend to August 31 on 5½ per cent. cumulative preference shares.

Herbert Morris, Limited.—Half-year's dividend for the half-year to July 31 on the 5 per cent. cumulative preference shares, free of tax.

J. Samuel White & Company, Limited.—Directors have decided to clear the four years' arrears of dividend on the 6 per cent. cumulative preference shares up to March 31 last.

Vickers, Limited.—Interim dividends for the half-year ended June 30, of 2½ per cent., less tax, on the preferred 5 per cent. stock; 2½ per cent., less tax, on the 5 per cent. preference stock, and 2½ per cent., free of tax, on the cumulative preference stock.

Contracts Open

Darlington, August 22.—112 ft. of 32-in. bore steel and cast-iron circulating water pipes, for the Town Council. The Borough Electrical Engineer, Electricity Works, Haughton Road, Darlington. (Fee £1, returnable.)

Wellington, N.Z., September 20.—Two low pressure and one high pressure centrifugal pumps, etc., for the Public Works Department. The Department of Overseas Trade. (Reference T.Y. 25,018/38.)

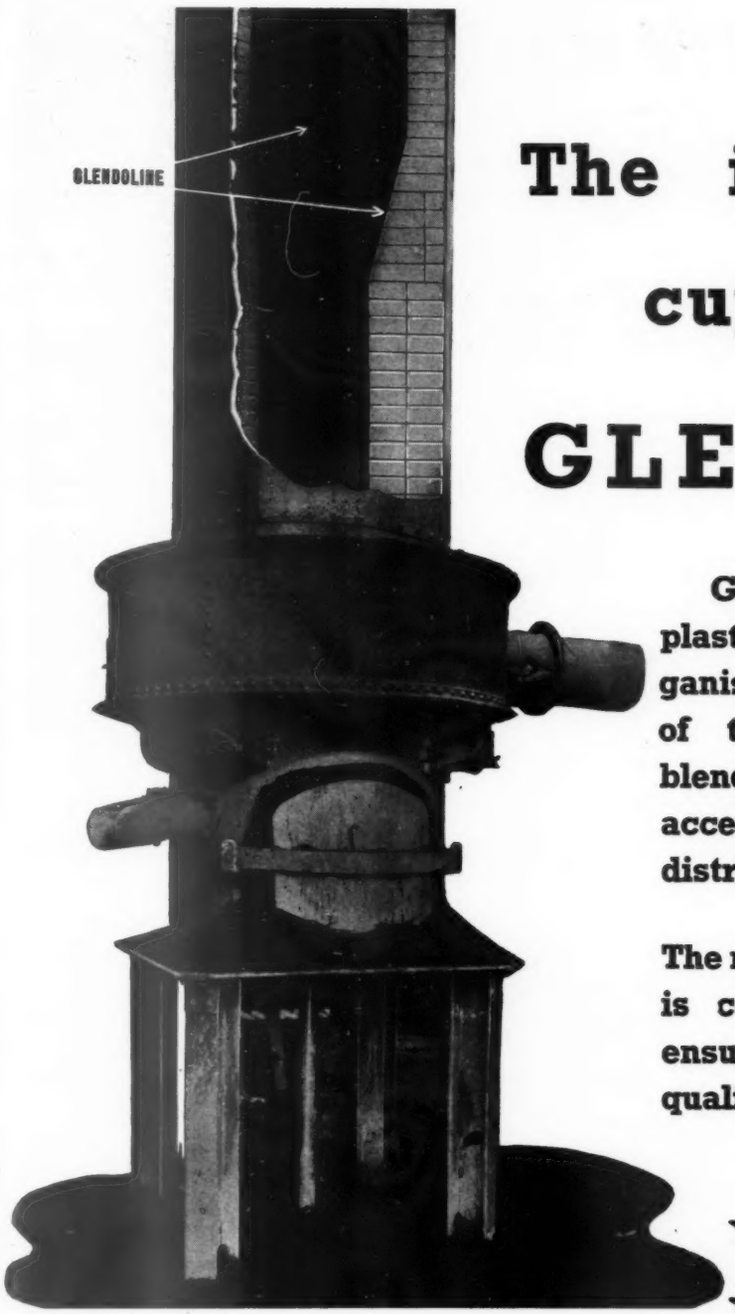
New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

J. R. Collyear, Limited.—Capital, £1,000. Ironmasters, founders, etc. Directors: J. R. Collyear, 19, Beachcroft Road, Bushey; S. L. Bapty, C. J. Glanville and E. W. Matthews.

"Loded" Iron

The last issue of the "Sheepbridge Stokes Magazine," published by the Sheepbridge Stokes Centrifugal Castings, Company, Limited, of Chesterfield, is entirely devoted to describing the properties and performance of what is claimed to be an entirely new product. Not much information is given as to the composition, but it obviously presents points of interest, because it follows the same principles as the Lanz Perlit system, but the material is centrifugally cast and contains something of the order of one per cent. chromium. The remainder of the composition is apparently balanced or "Loded," so as to yield an all-pearlitic structure. Much importance is given to the wearing properties of the skin of this material. As the process is the subject of patent applications, metallurgists will have to wait until the final publication of the specification to learn the methods and processes for this balancing.



★ This photograph of a cupola, shows a portion of the lining and the positions where Glendoline is recommended for lining and patching.

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Raw Material Markets

The past week has been a very quiet one for the iron and steel trades, owing to the general stoppage for holidays, which vary in length from district to district. Repairs are being carried out where necessary. With regard to the future, it is generally considered that there will be a revival of trade late in the autumn, but consumers' orders are not likely to be very substantial at all this year, for two reasons: first, in view of the fact that they have sufficient stocks on hand to meet any additional demands; and, secondly, prices, it is anticipated, will be reduced when they come up for revision at the year-end.

Pig-Iron

MIDDLESBROUGH.—Quite apart from the holiday interruptions, activity at the pig-iron producing plants is at a low ebb and is likely to remain so for the best part of the year. If, as is expected, there is a reduction of prices at the end of the year, it seems quite possible that buying will be resumed on a moderately good scale, but the fact must not be lost sight of that, in addition to having large stocks already on hand, many consumers have still large tonnages to be despatched under contracts entered into several months ago. Dorman, Long & Company, Limited, have decided to put out of action two blast furnaces at their Cleveland Works and to close coke-oven plant at their Newport Works. Of the 49 blast furnaces in the north-eastern area only 22 will be in blast when the furnaces at the Cleveland Works cease to operate. For deliveries up to December 31, No. 3 Cleveland G.M.B. iron is quoted at 109s. per ton in the Middlesbrough and Falkirk districts, and 112s. on the Clyde, less 5s. rebate.

Trade in hematite is extremely dull and current production, reduced as it is, is more than sufficient to meet all inquiries. Shipments abroad are restricted to very small parcels and no new business is being done, owing to the fact that Continental users are able to obtain material elsewhere at prices much below British quotations.

LANCASHIRE.—Makers of foundry pig-iron continue to experience considerable difficulty in disposing of supplies and it is not easy to despatch deliveries under contracts very regularly, as consumers are already overloaded with material and the rate of consumption is much lower than normal. Heavy-electrical and machine-tool concerns are still taking up satisfactory tonnages, but most other branches are dull. For delivery in the Lancashire price zone, Staffordshire and Derbyshire brands of No. 3 foundry iron are quoted on the basis of 114s., with Northamptonshire No. 3 at 112s. 6d., and Derbyshire forge iron at from 111s. to 113s. per ton, according to the class of consumer. Business in hematite continues to be restricted to small parcels.

MIDLANDS.—Owing largely to the incidence of holidays, the pig-iron market in this district is very subdued. Consumers are still engaged in working off stocks and are likely to continue to do this for several months. Consequently, makers are having to place a substantial proportion of their production into stock. The light-castings foundries remain the most disappointing section of the consuming industries and there is little likelihood of their returning to normal activity for a considerable time to come. Business in low-phosphorus iron naturally has been quiet this week, but it is expected that there will shortly be a renewal of activity; recently, quite large tonnages have been changing hands. The call for contract deliveries of hematite is satisfactory, but, owing to forward commitments, there is not much in the way of new orders to be obtained. The demand for both forge and refined irons is very small.

SCOTLAND.—Producers continue to report that there is a very scanty number of orders in circulation, and until stocks have been appreciably reduced from their present levels no new orders for tonnages of any size will be placed. In any case, makers will be able to meet inquiries from their own stocks for quite a time. The price of No. 3 foundry iron is unchanged at 118s. f.o.t. furnaces, with No. 1 at 2s. 6d. per ton more. A resumption of work has been made by the foundries in the Falkirk area, but short time continues to be general. The steelworks, also, have restarted after the holidays, and, while they are generally quite busy, most works have adequate supplies of pig-iron on hand.

Coke

Consumers of foundry coke are still refraining from placing orders for forward delivery, as they are of the opinion that current prices are too high, despite the reduction that producers made recently. In any case, consumption is at a lower level than usual, owing to the quietness of trade. It may be definitely assumed that there will be little improvement in the coke market before the turn of the year, when quotations are almost certain to be reduced still further. For delivery to Birmingham and Black Country stations, best Durham coke is quoted at 50s. 6d., with Welsh coke at from this figure up to 62s. 6d. per ton, according to analysis.

Steel

All sections of the steel market have been quiet during the past week, owing to the holiday interruption, but the outlook is viewed quite favourably in most quarters. It is confidently anticipated that there will be a pronounced revival of activity in the autumn. Stocks of semi-finished steel are heavy and the call for supplies is poor. Recently, there has been a steady decline in imports of semis, and this will naturally hasten the elimination of consumers' stocks. Business in finished steel is not unsatisfactory, on the whole, though orders of late have been few. The export section of the market continues to be very dull.

Scrap

Merchants' efforts to dispose of iron and steel scrap are meeting with but scant success. Many consumers are not in the position to take contract deliveries, while new business is almost in a state of total paralysis. The demand for a return to free marketing appears to be receiving increasing support, it being argued that this is likely to be the only way of reviving trade at all.

Metals

Steady conditions continue to prevail on the Metal Exchange. Additional confidence was forthcoming as a result of the Prime Minister's recent statement on the European situation.

Copper.—The interruption of the Bank holiday and the fact that many consuming plants are closed for the annual vacations have tended to keep the demand for copper down to a low level during the past week. On the Continent, business has been quite good. In the United States, there are indications that trade is beginning to increase and working-up plants have recently been rather more active. Consumption of copper in America still has a long way to go before it is up to a satisfactory level.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £40 13s. 9d. to £40 16s. 3d.; Friday, £41 6s. 3d. to £41 7s. 6d.; Tuesday, £41 3s. 9d. to £41 5s.; Wednesday, £41 13s. 9d. to £41 15s.

Three Months.—Thursday, £40 18s. 9d. to £41; Friday, £41 12s. 6d. to £41 13s. 9d.; Tuesday, £41 8s. 9d. to £41 10s.; Wednesday, £41 18s. 9d. to £42.

Tin.—The July issue of the Statistical Bulletin of the International Tin Research and Development Council, published by The Hague Statistical Office, states that total tin production for the first half of 1938 amounted to 82,000 tons, or 13,700 tons per month on an average, against 94,600 tons in the first half of 1937 and 113,300 tons in the second half. The figure for June 1938, is estimated at 11,500 tons, which is the lowest since September, 1935. World apparent tin consumption in the first five months of the year amounted to 69,800 tons, or 13,960 tons per month on an average, being a decrease of 16 per cent. as compared with the year 1937. Apparent consumption in the United Kingdom in June is given at 1,043 tons. The statistics for the consumption of tin in manufacture in 1938 have been revised, and the total for the first five months of 1938 is now estimated at 61,300 tons, or 12,300 tons per month on an average. World tinplate production in June amounted to 215,000 tons, being the lowest figure since 1934. The total for the first half of 1938 amounted to 1,465,000 tons, giving a monthly average of 234,000 tons, against an average of 355,000 tons in 1937.

A quiet tone has continued to pervade the market and the turnover this week has been very small. Only meagre tonnages are changing hands in the United States, also, but there has been something of an improvement in activity among tinplate manufacturers. Mills are now estimated to be operating around 35 per cent. of standard time.

Official quotations were as follow:—

Cash.—Thursday, £192 15s. to £193 5s.; Friday, £195 15s. to £196 5s.; Tuesday, £194 to £194 5s.; Wednesday, £195 5s. to £195 10s.

Three Months.—Thursday, £194 to £194 5s.; Friday, £197 to £197 5s.; Tuesday, £195 5s. to £195 10s.; Wednesday, £196 5s. to £196 10s.

Spelter.—Business has continued to be on the quiet side. The lack of steady working among the galvanisers remains an unsatisfactory feature of the market. The weekly market report issued by Rudolf Wolff & Company states that consumption is fairly well maintained, while, on the Continent, a firm market is reported, with producers still disinclined to press sales at current values. The rumours with regard to the reconstitution of the International Zinc Cartel, which were current a short while back, had apparently little foundation in fact, but the undertone, nevertheless, remains firm. The future of the market, subject to any marked increase in consumption, depends very largely on whether or not production continues to be gradually adjusted to balance consumption.

Daily market prices:—

Ordinary.—Thursday, £13 18s. 9d.; Friday, £14; Tuesday, £13 16s. 3d.; Wednesday, £13 17s. 6d.

Lead.—The tone of this market has been quite good, in fact, surprisingly strong for a holiday week. Cablemakers are the most active consumers at the present time and buying from this source has been on a good scale. There is still a noticeable lack of support from most other consuming industries, however.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £14 15s.; Friday, £15; Tuesday, £14 14s. 3d.; Wednesday, £14 12s. 6d.

Scrap.—The disposal of supplies of most grades continues to be problematical for merchants who have substantial tonnages for sale. Export inquiries for various descriptions of brass remain quite strong. The price of new aluminium cuttings has been reduced £6 per ton following the lowering of the virgin metal quotation.

Approximate selling prices for old metal:—New aluminium cuttings, £66; rolled, £55; cast, £28; foil, £88. Copper, £37 to £41; braziery, £33 to £34. Brass (clean), £22 to £25. Zinc, £9. Lead, £14. Gunmetal, £39.

Chains, Ropes and Lifting Tackle

The Home Office has issued S.R. & O. No. 599, Factories: The Chains, Ropes and Lifting Tackle (Register) Order, 1938, dated June 16, 1938, which prescribes that the register required to be kept under subsection (1) (*g*) of the Factories Act, 1937, with respect to all chains, ropes or lifting tackle (except fibre rope slings) used for the purpose of raising or lowering persons, goods or materials, shall contain the following particulars, namely:—(i) Name of occupier of factory; (ii) address of factory; (iii) distinguishing number or mark and description sufficient to identify the chain, rope or lifting tackle; (iv) date (if after June 30, 1938) when the chain, rope or tackle was first taken into use in the factory; (v) date of each examination made under Section 23 (1) (*d*), and by whom it was carried out; (vi) particulars of any defect found and affecting the safe working load, and of the steps taken to remedy such defect; (vii) date and number of the certificate relating to any test and examination made under Section 23 (1) (*e*) together with the name and address of the person who issued the certificate; (viii) dates of annealing or other heat-treatment. This Order is obtainable from H.M. Stationery Office, York House, Kingsway, London, W.C.2. (Price 1d. net.)

CONFIRMATION OF A REDUCTION of the capital of Armstrong Whitworth Securities Company, Limited, from £11,012,500 to £8,912,500, was made on July 25. The reduction was to be effected by paying back £2 100,000 to the two classes of preference shareholders.